

NEW SPECIES OF CENTRAL AMERICAN *CULICOIDES* LATREILLE
(DIPTERA: CERATOPOGONIDAE) WITH A SYNOPSIS OF SPECIES
FROM COSTA RICA

GUSTAVO SPINELLI AND ART BORKENT

(GS) Departamento Científico de Entomología, Museo de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina (e-mail: spinelli@museo.fonynm.unip.edu.ar); (AB) Research Associate, Royal British Columbia Museum, American Museum of Natural History, and Instituto Nacional de Biodiversidad, 1171 Mallory Road, Enderby, British Columbia, V0E 1V3, Canada (e-mail: aborkent@jetstream.net)

Abstract.—Ten new species of Central American *Culicoides* are described, illustrated and placed to subgenus or species group. Their position in previously published keys is indicated and their features discussed in light of the most recent revisions. Eight of the new species are known only from Costa Rica, one is known from Costa Rica and Panama and one is recorded from Honduras and El Salvador. The **new species** are named *Culicoides annettae*, *C. chaverrii*, *C. cummingi*, *C. hermani*, *C. hondurensis*, *C. monicae*, *C. picadoae*, *C. ronderosae*, *C. trifidus*, and *C. zumbadoi*. A list of 148 *Culicoides* species known or suspected of being in Costa Rica is given in a table. Of these, 42, including the new species, are recorded from Costa Rica for the first time. Most of the new species are recorded from mid to high elevations.

Resumen.—Se describen, ilustran y ubican en su respectivo subgénero o grupo de especies, a diez especies nuevas de *Culicoides* de América Central. Se indica su posición en las claves publicadas previamente, y sus caracteres distintivos se discuten a la luz de las revisiones más recientes. Ocho de las especies nuevas se conocen sólo para Costa Rica, una para Costa Rica y Panamá y la restante para Honduras y El Salvador. Las **especies nuevas** son nominadas *Culicoides annettae*, *C. chaverrii*, *C. cummingi*, *C. hermani*, *C. hondurensis*, *C. monicae*, *C. picadoae*, *C. ronderosae*, *C. trifidus* y *C. zumbadoi*. Se ofrece en una tabla, una lista de 148 especies de *Culicoides* conocidos o sospechados de ser hallados en Costa Rica, 42 de los cuales, incluyendo a las especies nuevas, son registrados por primera vez para Costa Rica. Muchas de las especies nuevas se registran para altitudes medias a elevadas.

Key Words: Ceratopogonidae, *Culicoides*, Costa Rica, Honduras, El Salvador, Central America, South America

Species in the genus *Culicoides* Latreille are by far the most notorious members of the 103 currently recognized genera of Ceratopogonidae. Not only is *Culicoides* the most diverse genus in the family, with 1,255 named extant species, but members occur virtually throughout the terrestrial

world, from the tropics to far southern and northern areas, from coastal areas to very high altitudes (up to 4,200 m). Many of these are miserable pests of humans and domestic animals and serve as vectors of a variety of diseases (Borkent, in press).

In spite of their economic, medical and

veterinary importance, it is surprising that the species of *Culicoides* of many areas remain poorly understood. The genus is so diverse that even in regions which have been studied for many years (e.g., United States), there are still quite a number of species represented in museums which remain to be described (and undoubtedly many more yet to be discovered!). Furthermore, there remains a great need to provide keys to species in some broader areas; there is still no key available to the species of either the United States or Canada!

In this paper we describe 10 additional species of *Culicoides* from Central America. We have been fortunate to have at hand the excellent treatment of the *Culicoides* of Panama by Wirth and Blanton (1959) and the wing atlas of Neotropical species by Wirth et al. (1988). We have indicated where each new species terminates in their key, with additional comments when more recent revisions are available. Borkent and Spinelli (2000) recently catalogued all species of Ceratopogonidae south of the United States and provided references to the most recent revisions and keys.

Although we have placed the new species in subgenera or species groups, readers should be aware that the current classification of *Culicoides* is in dire need of careful cladistic analysis. Some subgenera are "garbage can" groupings of species which cannot be placed elsewhere and every major region of the globe has species of *Culicoides* which cannot be placed even in those subgenera but are relegated to species groups or listed as "miscellaneous."

MATERIALS AND METHODS

All specimens were mounted on microscope slides using the technique described by Borkent and Bissett (1990). Terms for structures follow those used in the Manual of Nearctic Diptera (McAlpine et al. 1981). Terms for wing veins follow the system of the Manual of Nearctic Diptera, with modifications proposed by Szadziewski (1996) (Table 1). Names of veins are in upper case

Table 1. Terms for wing veins and cells as used here and by Wirth (and his coauthors) in his publications.

As Used in This Work	Wirth and Coauthors
Veins	
R ₁	R ₁
R ₂	radial crossvein
R ₃	Rs or R ₄₊₅
R ₄₊₅	intercalary of <i>Leptoconops</i>
M	M ₁₊₂
M ₁	M ₁
M ₂	M ₂
CuA ₁	M ₃₊₄
CuA ₂	Cu ₁
CuP	Cu ₂
A	A
Cells	
1 st radial cell	1 st radial cell (or 1 st anterior radial cell)
2 nd radial cell	2 nd radial cell (or 2 nd anterior radial cell)
r ₃	R ₅
m ₁	M ₁
m ₂	M ₂
cua ₁	M ₄
anal	anal

and those of cells in lower case. Pale areas in cell r₃ posterior to or immediately distal to the 2nd radial cell are called poststigmatic pale spots. More specific larval and pupal terms follow Lawson (1951). Ratios used are those explained in Spinelli et al. (1993).

Adults were collected by sweeping with an aerial net, with malaise traps or with light traps (a fluorescent bulb on a white sheet). Larvae and pupae were extracted through manual examination of substrates placed in shallow dishes or pans. Dates of collections of reared specimens refer to the date upon which the immatures were collected. Most of the specimens reported here have a "CD" number which refers to further collecting and habitat details in the junior author's personal collecting notes. Specimens are deposited in the following collections:

CNCI—Canadian National Collection of Insects, Ottawa, Ontario, Canada.

MLPA—Museo de la Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina.

INBC—Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica.

USNM—Smithsonian Institution, National Museum of Natural History, Washington, D.C., U.S.A.

Wing photomicrographs were taken with a Canon PowerShot, S40, digital camera through a Leica, DMLB, compound research microscope. Wings were photographed in either two or three sections at either 10× or 20× and the separate images assembled in Photoshop™, version 6.

RESULTS

Culicoides (Avaritia) hermani Spinelli and Borkent, new species (Figs. 1A, 2A–E, 10A)

Diagnosis.—Small adults in the *andicola* species group, very similar to *C. orjuelai* Wirth and Lee, from which it may be distinguished by the shorter distal flagellomeres, smaller number of mandibular teeth, tibiae with subbasal pale rings, the pale area centered on crossvein r-m broadly abutting costal wing margin, and the presence of a very faint, indistinct pale area in cell cua_1 .

Description.—Male. Similar to female with usual sexual differences. Wing length 1.15 mm; width 0.52 mm; CR 0.61. *Genitalia* (Fig. 2E): Tergite 9 subquadrangular, lacking apicolateral processes; sternite 9 short, with broad, deep posteromedial excavation. Gonocoxite with slender, pointed dorsal, ventral roots, the latter contacting at midline; gonostylus shorter than gonocoxite, moderately curved, tip pointed. Parameres (Fig. 2D) separate, each with short, stout anterolateral process, midportion slender, nearly straight, tapering to slender, filamentous, recurved tip. Aedeagus triangular; basal arch very low, extending 0.20 of

total length; lateral arms well sclerotized, tapering to short, posteromedial projection, tip blunt; with dorsal, subapical, sclerotized process present.

Female. *Head*: Dark brown. Eyes with numerous interommatidial spicules, contiguous by distance equal to diameter of 1.5 ommatidia. Flagellum (Fig. 2A) uniformly brown; flagellomeres 1–8 short, vasiform, 9–13 subcylindrical, stout to apices; AR 1.08 (1.00–1.16, $n = 5$); sensilla coeloconica on flagellomeres 1, 9–13. Palpus (Fig. 2B) brown; third segment with conspicuous irregular pit; PR 3.05 (2.90–3.40, $n = 5$); P/H ratio 1.03 (1.00–1.09, $n = 5$). Mandible with 15 ($n = 5$) teeth. *Thorax*: Dark brown, scutum with sublateral, faint paler bands. Legs brown, fore and midfemora pale apically, tibiae with narrow, subbasal rings; hind tibial comb with five spines, one nearest spur longest. Wing (Fig. 1A), length 1.25 (1.16–1.36, $n = 5$) mm; width 0.64 (0.60–0.68, $n = 5$) mm; CR 0.61 (0.59–0.63, $n = 5$); with pale areas much reduced; faint pale area near basal arculus continuous with basal pale area in anal cell; conspicuous pale spot centered on crossvein r-m, broadly abutting costal wing margin; poststigmatic pale spot in cell r_3 transverse, including distal half of second radial cell; very faint, indistinct pale area in cell cua_1 ; anal cell with distal rounded pale area. Macrotrichia very sparse, scattered on distal half of wing. Halter pale. *Abdomen*: Dark brown. Two ovoid, unequal spermathecae, tapering to moderately long necks (Fig. 2C), measuring 47 (44–53, $n = 5$) by 39 (36–44, $n = 5$) μm , and 38 (36–46, $n = 5$) by 34 (30–40, $n = 5$) μm ; rudimentary third, ring present.

Distribution.—*Culicoides hermani* is known only from high elevations in southern Costa Rica and northern Panama (Fig. 10A), from 1,600–2,750 meters. The adults from 15 km N San Isidro de el General were taken at Reserva Avalon, a few kilometers SW of División.

Bionomic information.—The holotype of *C. hermani* was swept from a flowering

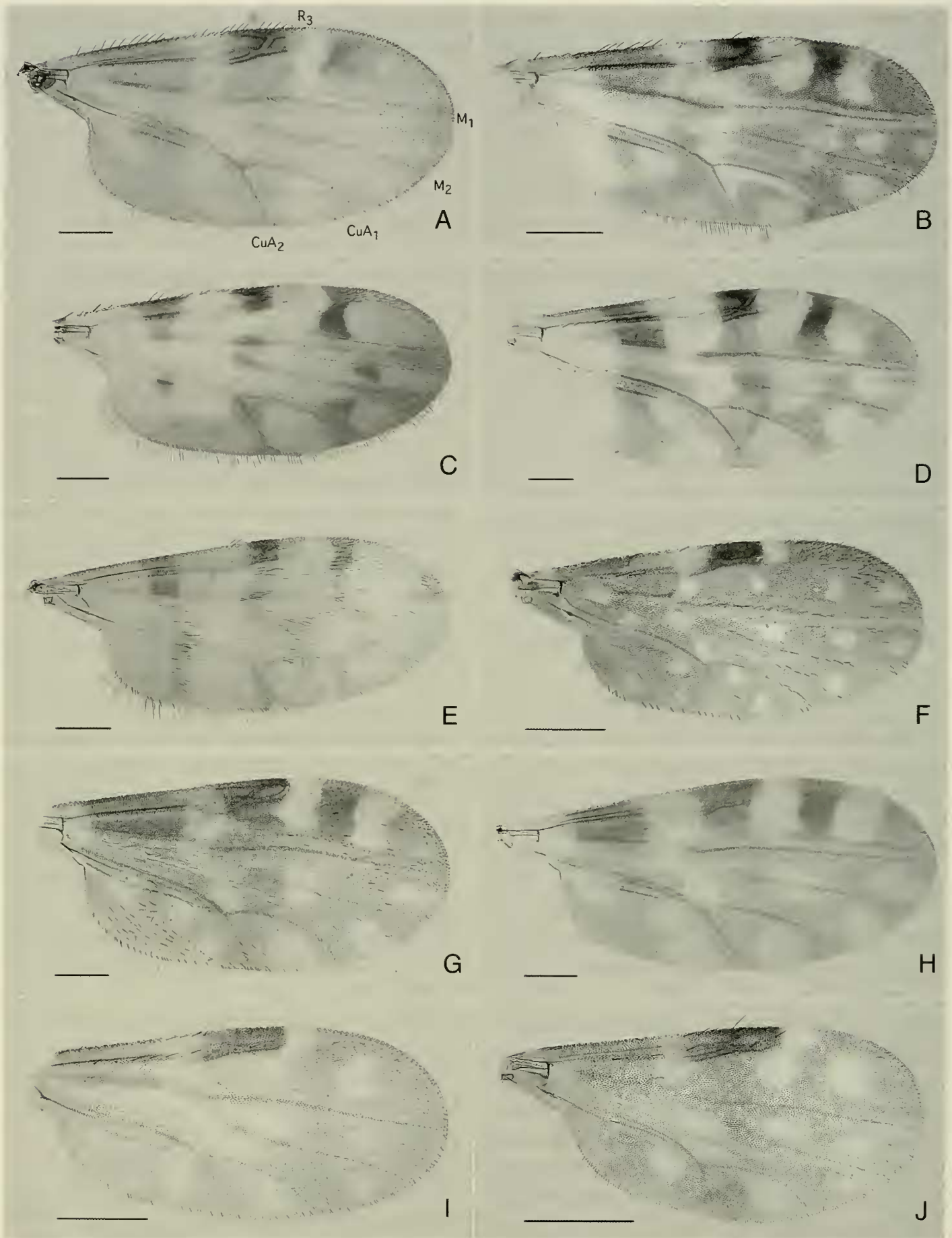


Fig. 1. Wings of female *Culicoides*. (A) *C. hermani*; (B) *C. annettae*; (C) *C. hondurensis*; (D) *C. monicae*; (E) *C. chaverrii*; (F) *C. ronderosae*; (G) *C. cummingi*; (H) *C. picadoae*; (I) *C. zumbadoi*; (J) *C. trifidus*. Scales = 0.2 mm.

bush on the trail leading up to Volcán Barú in northern Panama. The allotype female and two of the paratypes were taken while biting humans and one paratype female was collected from a light. Adults were present in high elevation cloudforest habitat and have been collected in March, September and October.

The female adult habit of biting humans and the presence of this species in higher altitudes is shared with the other Neotropical species of the *alticola* group, all four of which are restricted to elevations above 3,000 meters in Colombia (Rodriguez and Wirth 1986).

Taxonomic discussion.—*Culicoides hermani* is a member of the *andicola* species group of the subgenus *Avaritia*. This new species keys out in Wirth and Blanton (1959) to couplet 13 where it may be distinguished by the presence of a pale apical band on the fore and midfemora but with the hind femora entirely dark. As a member of the *andicola* species group, *C. hermani* will key in Rodriguez and Wirth (1986) to *C. puracensis* Wirth and Lee, a Colombian paramo species. Females of *C. hermani* can be distinguished from that species by the sensillar pattern (1, 11–13 in *C. puracensis*) and the flagellomere 9 without a distal constriction. Furthermore, male *C. hermani* lack the apicolateral processes on tergite 9 and the stouter distal posteromedial projection of aedeagus present in *C. puracensis*.

Wirth and Lee (1967) mention an undescribed Costa Rican species that is almost certainly the same as that described here as *C. hermani*.

The male and female were associated by the presence of shared wing pattern and body coloration. In addition, they represent the only species of the *alticola* species group in Costa Rica and Panama.

Types.—Holotype ♂, Panama, 8 km W Boquete, 21-IX-1993, 1,600 m, A. Borkent, CD1583 [CNCI]; allotype ♀, Costa Rica, 4 km N Sacramento, 10-X-1993, 2,750 m, A. Borkent, biting human, CD1609 [CNCI]. Paratypes, 4 ♀, as follows: same data as

allotype, 1 ♀ [MLPA]; Costa Rica, 15 km N San Isidro de el General, 2,250 m, 12-III-1999, A. Borkent, biting human, CD5000, 2 ♀ [CNCI]; Costa Rica, 15 km N San Isidro de el General, 2,250 m, 13/14-III-1999, A. Borkent, light trap, CD5002, 1 ♀ [INBC].

Derivation of specific epithet.—This species, the only one described herein which is known to bite humans, is named after the junior author's brother and dear friend Herman Borkent in recognition of his loving support through all the years.

Culicoides (Hoffmania) annettae Spinelli and Borkent, new species
(Figs. 1B, 2F–J, 3A–F, 10A)

Diagnosis.—Medium sized adults in the *guttatus* species group very similar to *C. ocumarensis* Ortiz, from which it can be distinguished by the slender third palpal segment with capitate sensilla in a shallow pit as well as in 2–3 other shallow depressions, the shorter proboscis, the distal pale spot in cell r_3 barely abutting the wing margin, the parameres broadly fused at their bases, and the aedeagus with a truncated apex.

Description.—Male. Similar to female with usual sexual differences. Wing length 0.94 mm; width 0.36 mm; CR 0.60. *Genitalia* (Fig. 2J): Tergite 9 with apicolateral processes very close together, posterior margin rounded, distinctly notched posteromedially; sternite 9 with moderately deep posteromedial excavation. Gonocoxite twice as long as broad; gonostylus slightly curved, apex pointed. Parameres (Fig. 2I) stout, broadly fused at base, apices slender, with minute fringing hairs. Aedeagus with low basal arch, extending 0.20 of total length; lateral arms slightly convex; posteromedial projection elongate, apex truncated.

Female. *Head*: Dark brown. Eyes bare, contiguous by distance equal to diameter of two ommatidia. Flagellum (Fig. 2F) brown, bases of flagellomeres 1–8 pale; AR 1.15 (1.10–1.18, $n = 4$); sensilla coeloconica on flagellomeres 1, 9–13. Palpus (Fig. 2G)

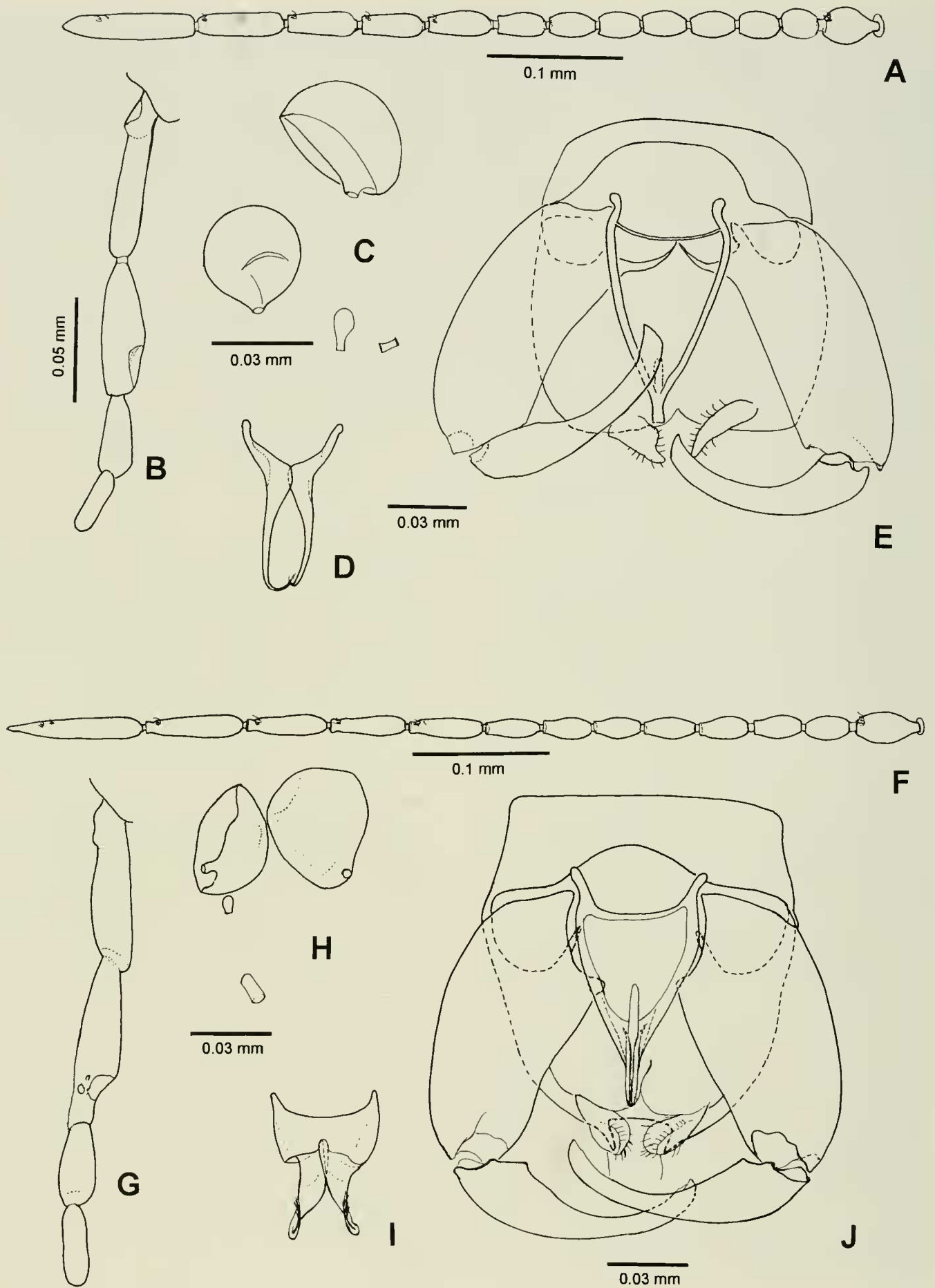


Fig. 2. Adult structures of *C. hermani* (A-E) and *C. amnettae* (F-J): (A, F) female antenna; (B, G) female palpus; (C, H) female spermathecae, duct ring; (D, I) parameres in ventral view; (E, J) male genitalia in ventral view.

dark brown; third segment slender with capitate sensilla in shallow pit and 2–3 other shallow depressions; long, slender portion beyond pit; PR 3.85 (3.70–4.00, $n = 4$); P/H ratio 0.92 (0.90–0.94, $n = 4$). Mandible with 16–17 ($n = 4$) teeth. *Thorax*: Scutum dark brown, with sublateral yellowish brown patches; scutellum, postscutellum dark brown. Legs dark brown, fore, mid knees, broad apex of hind tibia yellowish; hind tibial comb with five spines, second from spur longest. Wing (Fig. 1B), length 1.02 (0.94–1.14, $n = 4$) mm; width 0.47 (0.44–0.52, $n = 4$) mm; CR 0.66 (0.64–0.67, $n = 4$); with contrasting pattern; crossvein r-m pale; vein R_3 pale; transverse distal pale spot in cell r_3 barely abutting wing margin; two distal pale spots in cell m_1 (apical one very faint, nearly imperceptible in one paratype); distal pale spot in cell m_2 large, rounded, broadly abutting wing margin; pale spot in cell cua_1 connected with pale line bordering lower margin of vein CuA_1 ; anal cell with two distal pale spots; apices of veins M_1 , M_2 pale, apices of veins CuA_1 and CuA_2 dark. Macrotrichia scattered on distal fourth of wing, absent in cell cua_1 , anal cell. Halter brown. *Abdomen*: Dark brown. Two pyriform, unequal spermathecae (Fig. 2H), measuring 49 (48–50, $n = 3$) by 41 (38–44, $n = 3$) μm , and 43 (42–44, $n = 3$) by 37 (34–40) μm ; rudimentary third, ring present.

Pupa. Female exuvia pale yellowish brown. Length 2.30 mm. Body surface generally smooth with spicules present on head, between abdominal segments, dorsally on anal segment. Operculum (Fig. 3D) with OL 0.14 mm; OW 0.16 mm; OW/OL 0.87; with well-developed anteromarginal seta located on tubercle, with pore at tubercle base; well-developed medial projection situated near dorsal margin. One long, one shorter anterodorsal setae on short, rounded tubercle (Fig. 3C). One long, one short, slender dorsolateral setae (Fig. 3C). One slender dorsomedial seta (Fig. 3C). Six dorsal sensilla, i a thick, moderately elongate spine, ii, iii short, slender, iv elongate, slen-

der seta, v, vi pores (Fig. 3B). Two ventromedian setae minute, slender with bases abutting. Two ventrolateral setae elongate, one longer than other, bases close. Respiratory organ (Fig. 3E) brown, pedicel stout; mid third with sparse scale-like pointed spicules, with 9–10 spiracles on apical half; P/H 0.21. Metathorax completely divided but abutting medially, with scutum not protruding beyond posterior margin of metathorax. Abdomen with setae separate from one another (none on common tubercle). Segment 4 setal pattern (Fig. 3A) with 2 d.a.s.m. with i short, ii elongate; 5 d.p.m. with i very short, ii, iii pores, iv short, thick, v elongate, slender; l.a.s.m. short, thick spine; 3 l.p.m. with i, iii moderately sized, thick, ii elongate, slender; 3 v.p.m. with i short, slender, ii, elongate, slender, iii very short peg. Anal segment (Fig. 3F) length 0.20 mm, width 0.15 mm; dorsal surface with sparse, posteriorly directed tubercles on mid portion, also present on posterolateral processes, latter directed posteriorly.

Distribution.—*Culicoides annettae* is recorded from lowland areas on both the east and west coasts of Costa Rica (Fig. 10A).

Bionomic information.—The holotype, allotype and some paratypes were collected with a light trap near the Tarcoles River estuary. A single female reared from a pupa was collected from a freshwater spring situated just west of Reserva Carara. The female from 10 km NW Cahuita was collected with a light trap at Aviarios del Caribe, a lodge situated on the delta of the Estrella River on the east coast. Adults were present in December and January.

Taxonomic discussion.—*Culicoides annettae* is a member of the *guttatus* species group within the subgenus *Hoffmania* Fox. This new species keys out in Wirth and Blanton (1959) to couplet 7 and within that couplet would run to *C. diabolicus* Hoffman except that *C. annettae* has a dark halter knob. The male further differs from *C. diabolicus* in possessing an aedeagus with a truncated apex. Spinelli et al. (1993) reviewed the *Culicoides guttatus* group for

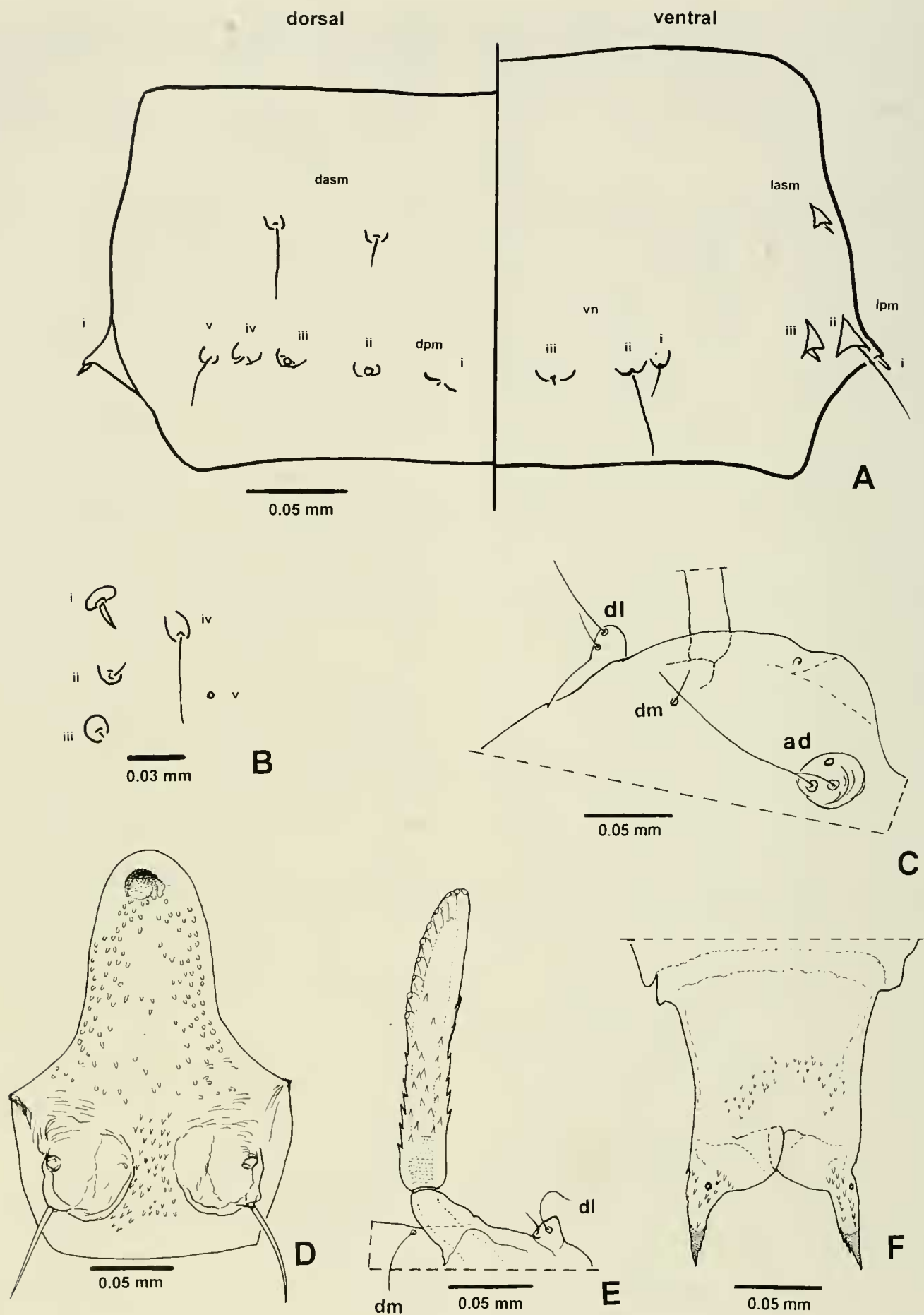


Fig. 3. Pupal structures of *C. ammettae*. (A) abdominal segment four; (B) right dorsal setae; (C) dorsolateral (dl), dorsomedial (dm), anterodorsal (ad) setae; (D) operculum; (E) respiratory organ, dorsomedial (dm), dorsolateral (dl) setae; (F) anal segment in dorsal view.

the Neotropics and *C. annettae* keys out to *C. ocumarensis* in couplet 14 of that work. However, *C. annettae* may be distinguished from that species by the features mentioned above in the diagnosis.

Culicoides paraignacioi Spinelli shares the slender third palpal segment and the truncate apex of aedeagus with *C. annettae*. However, the third palpal segment of *C. paraignacioi* bears an unique, definite sensory pit and crossvein r-m is clearly dark on its anterior half.

Of the 38 Neotropical species of *Culicoides* in the subgenus *Hoffmania*, only four have been described as pupae: *C. charruus* Spinelli and Martinez, *C. hylas* Macfie, *C. insignis* Lutz and *C. maruim* Lutz. The pupa of *C. annettae* has a more spinose respiratory organ than *C. hylas*, a respiratory organ with a row of spiracles distributed along its apical half (apical in *C. charruus*, *C. insignis* and *C. maruim*).

The male and female were associated by similar pigmentation patterns and were collected together at Tarcoles.

Types.—Holotype ♂, allotype ♀, Costa Rica, Tarcoles, 1-I-1994, A. Borkent, CD1730 [CNCI]. Paratypes, 3 ♀, as follows: same data as holotype, 1 ♀ [MLPA]; Costa Rica, 2 km NE Tarcoles, 17-XII-1993, A. Borkent, CD1714, 1 ♀ (with pupal exuvia) [CNCI]; Costa Rica, 10 km NW Cahuita, 9-XII-1993, A. Borkent, CD1700, 1 ♀ [INBC].

Derivation of specific epithet.—This species is named for the junior author's wife, who shared the joys and many of the tasks of an expedition to Costa Rica in 1993–1994 which resulted in the collection of all the type material.

***Culicoides (Culicoides) hondurensis*
Spinelli and Borkent, new species**
(Figs. 1C, 4A–F, 10B)

Diagnosis.—Large adults in the subgenus *Culicoides* very similar to *C. luteovenus* Root and Hoffman, from which it can be distinguished by the irregular palpal pit, the scutum without a definite pattern, the

wing background white and the tip of aedeagus truncate.

Description.—Male. Similar to female with usual sexual differences. Flagellum as in Fig. 4A. Wing length 1.38 (1.26–1.52, n = 5) mm; width 0.47 (0.43–0.51, n = 5) mm; CR 0.58 (0.57–0.60, n = 5). *Genitalia* (Fig. 4F): Tergite 9 rounded posteriorly, apicolateral processes moderately developed, slender, undivided posteromedial lobe well developed, with thickening on midline; sternite 9 short, with broad, shallow posteromedial excavation. Gonocoxite with short dorsal, ventral roots, mesal margin with heavy spinose setae; gonostylus lightly sclerotized on distal half, apex blunt, rounded. Parameres (Fig. 4E): Separate, each with stout, abruptly bent base, stout and nearly straight basal portion, apically slender, bent, hairy. Aedeagus triangular; basal arch extending 0.25–0.33 of total length with faintly sclerotized membrane across distal half; lateral arms well sclerotized; apex slender, truncated.

Female. *Head*: Dark brown. Eyes bare, contiguous by distance equal to diameter of 2–3 ommatidia. Flagellum (Fig. 4B) uniformly dark brown; flagellomeres 1–8 vaseiform, 9–13 subcylindrical; AR 0.98 (0.92–1.07, n = 10); sensilla coeloconica on flagellomeres 1, (2–3), (5–8), 9–13 (only one specimen with sensilla on flagellomeres 2–3). Palpus (Fig. 4C) brown; third segment with conspicuous irregular pit; PR 2.82 (2.55–3.10, n = 10); P/H ratio 0.76 (0.70–0.81, n = 10). Mandible with 14 (13–16, n = 10) teeth. *Thorax*: Dark brown, scutum without definite pattern. Legs dark brown, knees narrowly yellowish, hind tibia pale at extreme base; hind tibial comb with six spines, second from spur longest. Wing (Fig. 1C), length 1.36 (1.20–1.45, n = 10) mm; width 0.61 (0.58–0.65, n = 10) mm; CR 0.62 (0.60–0.65, n = 10); with white background, pattern roughly in form of three dark zig-zag bands, each more or less broken into separate dark spots centering on veins; distal pale spot in cell r₃ occupying entire apex of cell to wing margin; distal

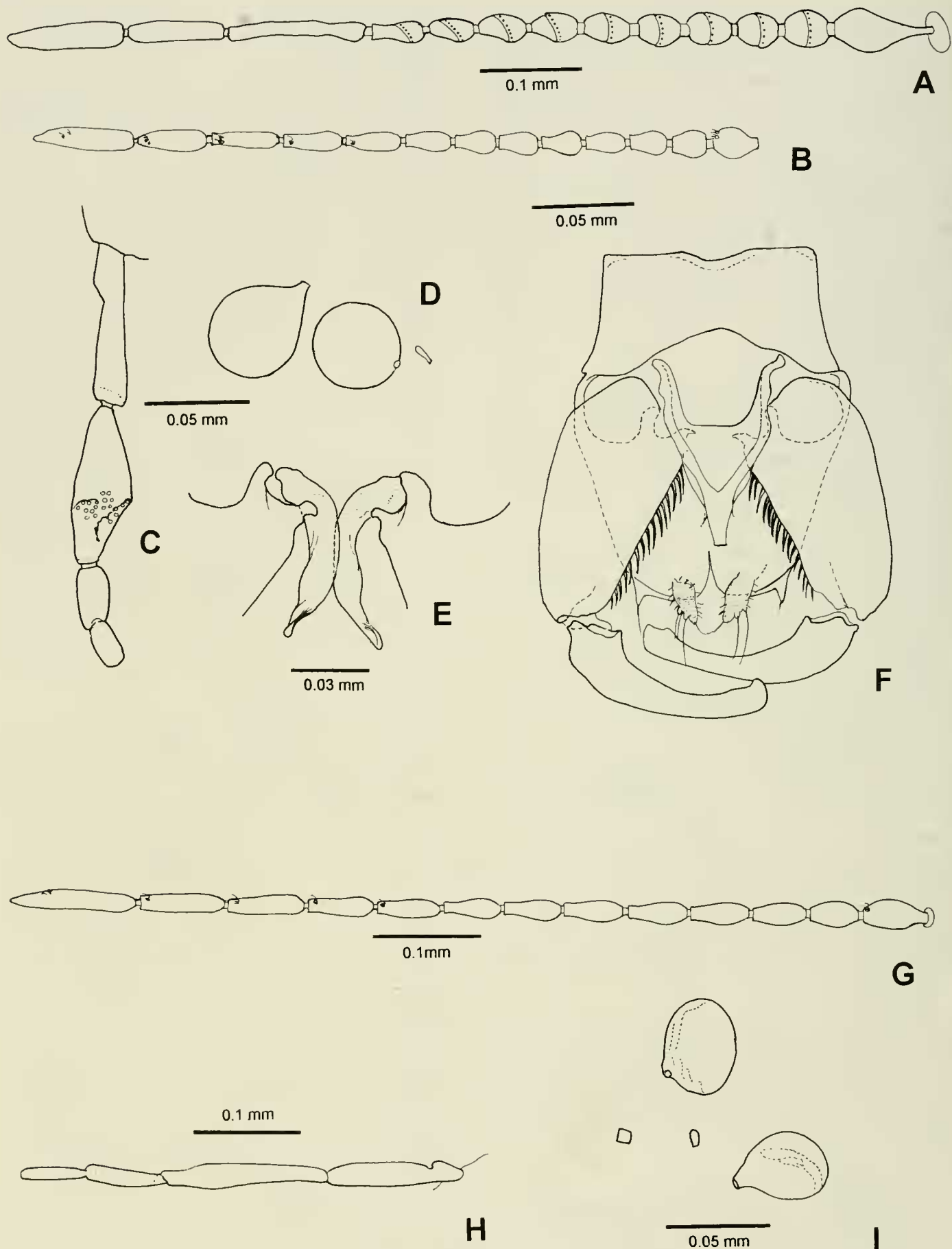


Fig. 4. Adult structures of *C. hondurensis* (A-F) and *C. monicae* (G-I): (A) male antenna; (B, G) female antenna; (C, H) female palpus; (E, I) female spermathecae, duct ring; (E) parameres in ventral view; (F) male genitalia in ventral view.

pale spots in cells m_1 and m_2 broadly abutting wing margin; pale spot in cell cua_1 large. Macrotrichia numerous on distal $\frac{2}{3}$ of wing. Halter yellowish. *Abdomen*: Dark brown. Two pyriform, subequal spermathecae (Fig. 4D), each measuring 62 (56–70, $n = 10$) by 45 (42–48, $n = 10$) μm ; rudimentary third present.

Distribution.—This species is known from a number of localities El Salvador, Honduras (Fig. 10B), ranging from 690–991 meters.

Bionomic information.—Adults have been collected throughout the year, from January to December.

Taxonomic discussion.—This new species keys out in Wirth and Blanton (1959) to *C. elutus* in couplet 14. The male differs from that species by the presence in *C. hondurensis* of a longer, tapering aedeagus and a more stoutly developed posteromedial projection on tergite 9. The female differs from *C. elutus* by its larger size, the presence of sensilla coeloconica on flagellomeres 2–3 and 5–8 in many specimens, the third palpal segment with an irregular sensory pit, and apex of the hind tibia without a narrow yellowish band. Adults of this species also resemble *C. neopulicaris* Wirth, a species distributed from Louisiana and Texas in the USA to Costa Rica, by virtue of the irregular palpal pit and wing with white background. Adults of *Culicoides neopulicaris*, however, have a conspicuous dark spot in the middle of cell cua_1 , the apicolateral processes of the male are practically absent, and the basal arch of the aedeagus is higher and its tip broadly rounded.

The thick spines on the inner surface of the gonocoxite appear to be a synapomorphy of at least some species in the subgenus *Culicoides*. The four Neotropical species *C. elutus*, *C. hondurensis*, *C. luteovenus* and *C. neopulicaris* bear these spines, as do the males of all Nearctic species we have examined.

The male and female were associated by being collected these together at several lo-

cations and on several different dates. There are only three other species of the subgenus *Culicoides* in the area south of the United States and the fact that both males and females were distinctive corroborates their association.

Types.—Holotype δ , allotype ♀ , Honduras, Comayagua, Siguatepeque, II-1965, F.S. Blanton [MLPA]. Paratypes, 101 ♀ , 13 δ , as follows: same data as types, 17 ♀ , 5 δ [9 ♀ , 3 δ , MLPA; 2 ♀ , 2 δ , USNM; 2 ♀ , INBC; 4 ♀ , CNCI]; same data except IX-1966, 3 ♀ [MLPA]; same data except III-1967, 3 ♀ , 1 δ [2 ♀ , 1 δ MLPA; 1 ♀ CNCI]; same data except 3-VII-1966, J.F. Matta, 1 ♀ [MLPA]; same data except 6-VII-1966, 1 ♀ [MLPA]; same data except 16-VII-1966, 3 ♀ [MLPA]; same data except 21-VII-1966, 1 ♀ , 1 δ [MLPA]; same data except 25-VII-1966, 1 ♀ [MLPA]; same data except 26-VII-1966, 1 ♀ [MLPA]; same data except VIII-1967, 1 δ [CNCI]; Copán, Santa Rosa, 26-V-1966, J.F. Matta, 2 ♀ [MLPA, CNCI]; same data except 30-VI-1966, 1 ♀ [CNCI]; same data except 7-VII-1966, 1 ♀ [MLPA]; same data except 21-VII-1966, 2 ♀ [MLPA]; same data except 24-VII-1966, 1 ♀ [MLPA]; same data except X-1966, F.S. Blanton, 18 ♀ , 1 δ [13 ♀ , 1 δ , MLPA; 2 ♀ , USNM; 3 ♀ , CNCI]; same data except XII-1966, 20 ♀ [17 ♀ MLPA; 2 ♀ CNCI; 1 ♀ INBC]; same data except I-1967, 4 ♀ [MLPA]; Francisco Morazán, Zamorano, 8-VII-1966, J.F. Matta, 1 δ [MLPA]; same data except 12-VI-1966, 1 δ [CNCI]; same data except 22-VII-1966, 1 ♀ [MLPA]; same data except 24-VII-1966, 1 ♀ [MLPA]; same data except X-1966, F.S. Blanton, 17 ♀ , 1 δ [13 ♀ , MLPA; 2 ♀ , USNM; 2 ♀ , 1 δ , CNCI]. El Salvador, San Vicente, Santo Domingo, II-1967, F.S. Blanton, 1 ♀ [MLPA]; Sonsonate, Armenia, III/IV-1967, F.S. Blanton, 1 ♀ , 1 δ [MLPA].

Derivation of specific epithet.—The name of this species reflects the presence of the majority of the collecting records from Honduras.

Culicoides (Anilomyia) monicae Spinelli
and Borkent, new species
(Figs. 1D, 4G–I, 10A)

Diagnosis.—Large adults in the *covagarciai* species group very similar to *C. marshi* Wirth and Blanton, from which it can be distinguished by the narrowly contiguous eyes, the more slender third palpal segment and absence of a sensory pit, and a longer proboscis.

Description.—Male. Unknown.

Female. *Head*: Dark brown. Eyes bare, barely contiguous, V-shaped where eyes contact. Flagellum (Fig. 4G) pale brown, flagellomeres 5–8 bottle-shaped, 9–13 subcylindrical, moderately elongated; AR 0.93 (0.91–0.96, $n = 3$); sensilla coelocnica on flagellomeres 1, 9–13. Palpus (Fig. 4H) dark brown; third segment very slender without sensory pit, sensilla scattered on surface; PR 6.50 (6.00–7.00, $n = 3$); P/H ratio 1.56 (1.52–1.60, $n = 3$). Mandible with 28 ($n = 3$) teeth. *Thorax*: Specimens not in position to describe scutum pattern. Legs brown; broad yellowish bands apically on fore and mid femora, basally on tibiae; apex of hind tibia yellowish. Wing (Fig. 1D), length 1.57 (1.34–1.77, $n = 3$) mm; width 0.72 (0.64–0.80, $n = 3$) mm; CR 0.64 (0.63–0.66, $n = 3$); predominantly pale, base broadly pale; crossvein r-m included in broad pale area abutting costal wing margin, which also includes $\frac{2}{3}$ of first radial cell; second radial cell, except extreme base, included in large pale area; three narrow, transverse, dark bands across wing: one before level of crossvein r-m, one at level of vein R_2 to cubital fork and a sinuate band from just past apex of costa to tip of vein CuA_1 ; cell r_3 with subapical, large pale spot; distal pale spot in cell m_1 separated from wing margin; distal pale spots in cells m_2 , cua_1 broadly abutting wing margin; two distal, rounded, narrowly connected pale spots in anal cell; pale spot straddling middle of vein M_2 . Macrotrichia scattered on distal half of wing, also present in anal cell. Halter pale. *Abdomen*: Brown.

Two pyriform, slightly unequal spermathecae (Fig. 4I), measuring 46 (44–48, $n = 3$) by 38 (36–40, $n = 3$) μm , and 40 (36–44, $n = 3$) by 33 (30–36, $n = 3$) μm ; rudimentary third present.

Distribution.—*Culicoides monicae* is known from two localities in Costa Rica (Fig. 10A) at mid elevations (1,000–1,800 meters).

Bionomic information.—This species is recorded from cloudforest habitat in the Talamanca mountains of Costa Rica and has been collected in March and August.

Taxonomic discussion.—*Culicoides monicae* belongs in the *covagarciai* species group of the subgenus *Anilomyia*. It keys to *C. marshi* in couplet 16 in Wirth and Blanton (1959), with the exception that *C. monicae* lacks the sensory pit on the third palpal segment. Wirth and Blanton (1956) reviewed the *Culicoides covagarciai* species group for the Neotropics, and the species also keys out to *C. marshi* in couplet 2 in that work (again with the exception of the sensory pit feature).

Of the nine species now recognized in the *covagarciai* species group, *C. monicae* and *C. marshi* have the most elongate third palpal segment. The two are easily distinguished by examination of the broadly contiguous eyes of *C. marshi*, which are narrowly touching in *C. monicae*. *Culicoides efferus* Fox also has a somewhat elongate palpus with a small subapical pit and its legs are uniformly light yellow.

Types.—Holotype ♀, Costa Rica, Cartago, P.N. Tapanti, 1,800 m, VIII-1997, R. Delgado, CD5016 [INBC]. Paratypes, 3 ♀, as follows: same data as type, 1 ♀ [CNCI]; Costa Rica, Cartago, P.N. Tapanti, 1,800 m, M. Alfaro, CD5043, 1 ♀ [INBC]; Costa Rica, Puntarenas, San Vito de Java, 22-III-1964, F.S. Blanton, 1 ♀ [MLPA].

Derivation of specific epithet.—The name *monicae* is proposed for the senior author's wife, in recognition of her loving support throughout the past fifteen years.

Culicoides (Anilomyia) chaverrii Spinelli
and Borkent, new species

(Figs. 1E, 5A–I, 6A–H, 7A–B, 11A)

Diagnosis.—Medium sized adults in the *decor* species group very similar to *C. lutealaris* Wirth and Blanton, from which it can be distinguished by the absence of sensilla coeloconica on flagellomeres 2–5 and 7 in most specimens, the third palpal segment not greatly swollen, the presence of a shallow sensory pit, the elongated gonocoxite, and the aedeagus with a blunt tip.

Description.—Male. Similar to female with usual sexual differences. Wing length 1.24 (1.16–1.40, $n = 5$) mm; width 0.48 (0.44–0.56, $n = 5$) mm; CR 0.57 ($n = 5$). **Genitalia** (Fig. 5E): Tergite 9 long, with stout apicolateral processes, the posteromedial margin distinctly notched; sternite 9 short, with broad, shallow posteromedial excavation. Gonocoxite 2.5 \times as long as broad (basally), gradually tapering posteriorly, dorsal, ventral roots slender, the later slightly bent apically; gonostylus distinctly shorter than gonocoxite, nearly straight, with pointed recurved tip. Parameres (Fig. 5D) separate, each with bent, knobbed base; basal portion slender, slightly sinuate, tapering to very slender, recurved, simple pointed apex. Aedeagus triangular; lateral arms strongly sclerotized; basal arch angulose, extending 0.50 of total length; posteromedial projection tapering to blunt tip.

Female. **Head:** Dark brown. Eyes bare, narrowly separated by distance shorter than diameter of one ommatidium. Flagellum (Fig. 5A) pale brown, especially flagellomeres 1–8; flagellomeres 1–8 short, 9–13 subcylindrical; flagellomere 9 1.1 as long as 7–8 combined; AR 1.45 (1.23–1.56, $n = 10$); sensilla coeloconica on flagellomeres 1, (2–5), 6, (7), 8–13. Palpus (Fig. 5B) dark brown; third segment with large subapical deep pit; PR 2.19 (2.02–2.30, $n = 10$); P/H ratio 0.69 (0.65–0.72, $n = 10$). Mandible with 14 (13–16, $n = 10$) teeth. **Thorax:** Scutum light brown or yellow, with sublateral brown longitudinal bands, very small dark

patch just anterior to margin of scutellum; scutellum yellowish brown, postscutellum dark brown. Legs brown, knee spots blackish; femora with subapical, tibiae with subbasal broad pale bands; hind tibial comb with four spines, one nearest spur longest. Wing (Fig. 1E), length 1.37 (1.24–1.52, $n = 10$) mm; width 0.65 (0.60–0.70, $n = 10$) mm; CR 0.60 (0.59–0.63, $n = 10$); appearing yellowish with narrow, sometimes broken, transverse dark bands, spots as figured; dark transverse band across midline of cell r_3 about a third as broad as yellow bands on each side; proximal pale spot in cell r_3 large, including distal portion of second radial cell, produced beyond vein M_2 ; distal pale spot in cell r_3 separated from wing tip by small dark area; distal pale spots in cells m_1 , m_2 , cua_1 , anal cell broadly abutting wing margin; basal transverse dark band interrupted in base of cell m_2 ; rounded pale spot straddling middle of vein M_2 isolated. Macrotrichia abundant, extending nearly to base of anal cell. Halter pale. **Abdomen:** Tergites pale, sternites medium brown, pleura blackish. Two pyriform, subequal spermathecae (Fig. 5C), each measuring 54 (48–60, $n = 10$) by 45 (38–50, $n = 10$) μ m; rudimentary third present.

Pupa. Male, female exuvia yellowish brown. Length 2.36 (2.20–2.50, $n = 5$) mm. Body surface generally smooth with spicules or very small tubercles present on dorsal and ventral surface of cephalothorax, anterolateral margins of abdominal tergites, entire dorsal and anteroventral surface of anal segment. Operculum (Fig. 6A) with OL 0.170 (0.150–0.200, $n = 5$) mm; OW 0.200 (0.180–0.226, $n = 5$) mm; OW/OL 1.18 (1.07–1.25, $n = 5$); central disk covered with abundant rounded tubercles; two well developed anteromarginal tubercles, bearing long, stout seta, with pore at tubercle base; well-developed medial projection situated near dorsal margin. Two anterodorsal setae on short, rounded tubercle, one long, slender, one a short peg (Fig. 5G). Three moderately thick dorsolateral setae, one shorter, one moderate in length, one

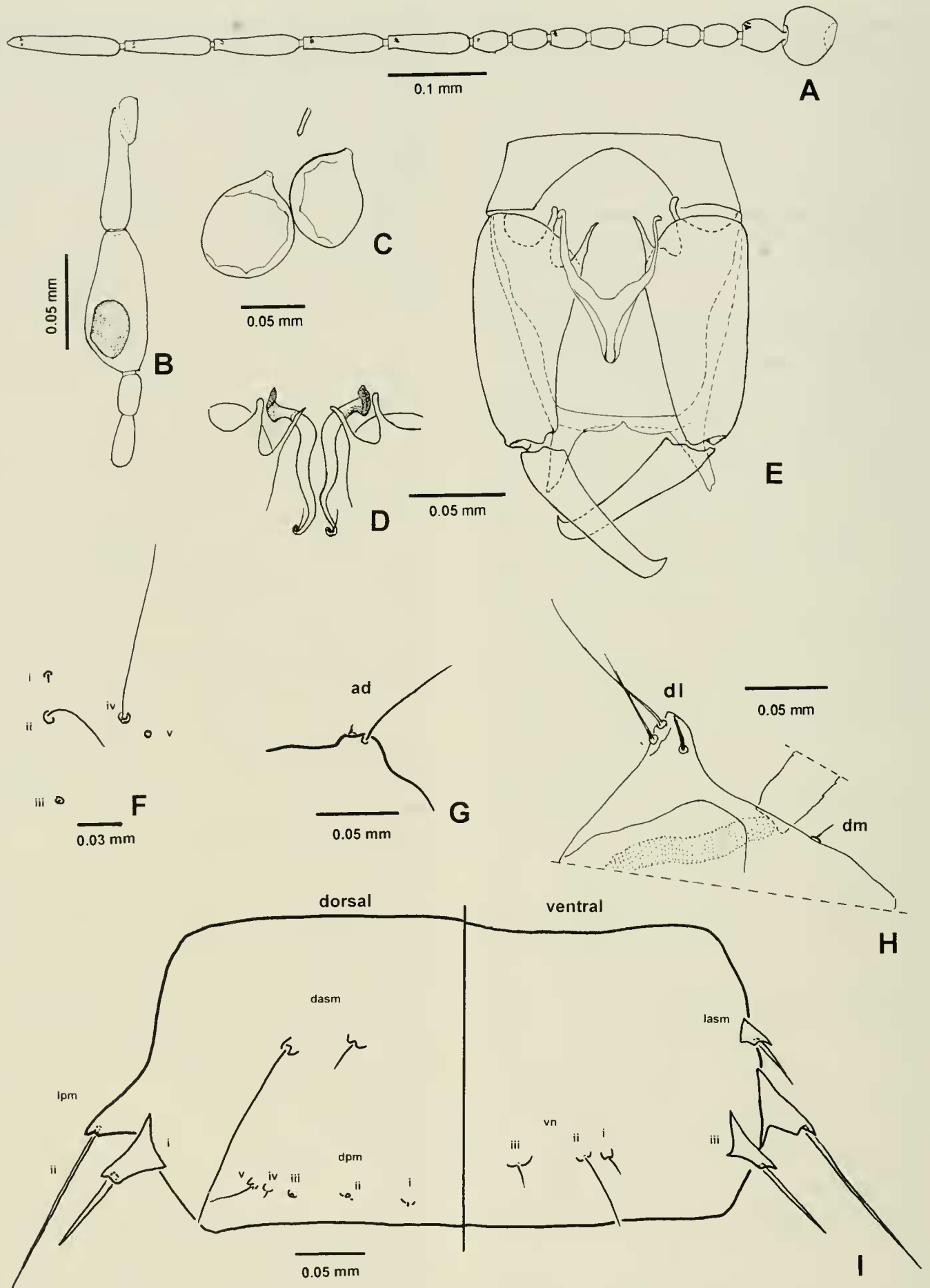


Fig. 5. Structures of *C. chaverrii*, adult (A-E), pupa (F-I): (A) female antenna; (B) female palpus; (C) female spermathecae; (D) parameres in ventral view; (E) male genitalia in ventral view; (F) right dorsal setae; (G) anterodorsal (ad) setae; (H) dorsolateral (dl), dorsomedial (dm) setae; (I) abdominal segment four.

elongate (Fig. 5H). One elongate, slender dorsomedial seta (Fig. 5H). Six dorsal sensilla, i, iii very short setae; ii elongate, slender, iv very elongate, slender seta, v, vi pores (Fig. 5F). Two ventromedian setae absent or perhaps a barely visible single pore. Two ventrolateral setae, one shorter, more slender than other, bases close. Respiratory organ (Fig. 6B) golden brown, pedicel very reduced; with scale-like pointed spicules, along entire length but more abundant on basal half; with 2–3 lateral, 8–9 apical spiracles; P/H 0.035 (0.020–0.047, $n = 5$). Metathorax completely divided medially, with scutum protruding to posterior margin of metathorax. Abdomen with setae separate from one another (none on common tubercle). Segment 4 setal pattern (Fig. 5I) with 2 d.a.s.m. with i short, ii very elongate; 5 d.p.m. with i very short peg, ii, iii pores, iv short, thick, v elongate, slender; l.a.s.m. moderately elongate, thick spine; 3 l.p.m. very well developed, with i, iii moderately sized, thick, ii very elongate, thick; 3 v.p.m. with i, iii short, thick, ii, elongate, slender. Anal segment (Fig. 6C) length 0.20 mm, width 0.15 mm; posterolateral processes directed posterolaterally.

Fourth instar larva. Total length approximately 4.00 mm: Head capsule (Figs. 6D–E) yellowish brown, medium-sized, stout with rounded apex; HL 0.252 (0.240–0.266, $n = 6$) mm; HW 0.187 (0.180–0.200, $n = 6$) mm; HR 1.35 (1.20–1.48, $n = 6$); SGW 0.113 (0.100–0.130, $n = 6$) mm; SGR 1.66 (1.48–1.80, $n = 6$); collar somewhat darker than rest of head capsule, well-developed ventrally with short anterior apodeme, separated medially; dorsolateral portion thick, not extending medially. Frontal suture extending to near anterior margin of labrum. Ventral suture well developed. Setae all simple, arrangement and sizes as in Figs. 6D–E. Antenna short, details not visible. Eye unknown. Labrum short, wide, further details not discernible. Premandibles small, triangular, apparently unarmed. Mandible (Fig. 6G) strongly sclerotized; small, broad at base, single stout hooked tooth,

medial protuberance slender, subbasal sensilla present but state uncertain. Epipharynx (Fig. 7A) with only two combs: dorsal comb sclerites short, with seven angular, lanceolate, unequal teeth/sclerite on each side; comb 4 short, with seven pointed teeth; curtains absent. Hypopharynx (Fig. 7B) with slender arms; anterior end short, triangular, with reduced minute teeth. Hypostoma (Fig. 6H) broad, without medial protuberance, with numerous small laterally placed, pointed teeth. Body pigmentation unknown. Caudal segment (Fig. 6F) greatly elongated, with six dorsal and six ventral long, stout, subequal caudal setae; CSL 0.49 (0.44–0.52, $n = 3$) mm; CSW 0.20 (0.16–0.24, $n = 3$) mm; CSR 2.46 (2.16–2.75, $n = 3$); anal papillae slender, forked.

Distribution.—*Culicoides chaverrii* is recorded from the Tilaran and Talamanca mountains of Costa Rica (Fig. 11A). The species appears to be a mid to high elevation species, recorded from 1,540–2,270 meters.

Bionomic information.—Series of specimens have been reared from larvae and pupae collected from both arboreal and ground-level bromeliads and a treehole in the Talamanca mountains. Of the seven other Neotropical species in the *decor* species group, the only two which are known as immatures have been also reared from bromeliads (Wirth and Blanton 1970). Adults were collected with a light trap in the Tilaran mountains (at Refugio Biológico Monteverde) and adults or reared adults have been collected in June and August.

Taxonomic discussion.—*Culicoides chaverrii* belongs in the *decor* species group of the subgenus *Anilomyia*. The adults of this new species key out to *C. lutealaris* in couplet 21 in Wirth and Blanton (1959), based on leg coloration; the wing length of *C. chaverrii* is somewhat shorter than that of *C. lutealaris*. The two species may be distinguished using the features given in the diagnosis above.

Culicoides nigrigenus Wirth and Blanton is another similar species which also occurs

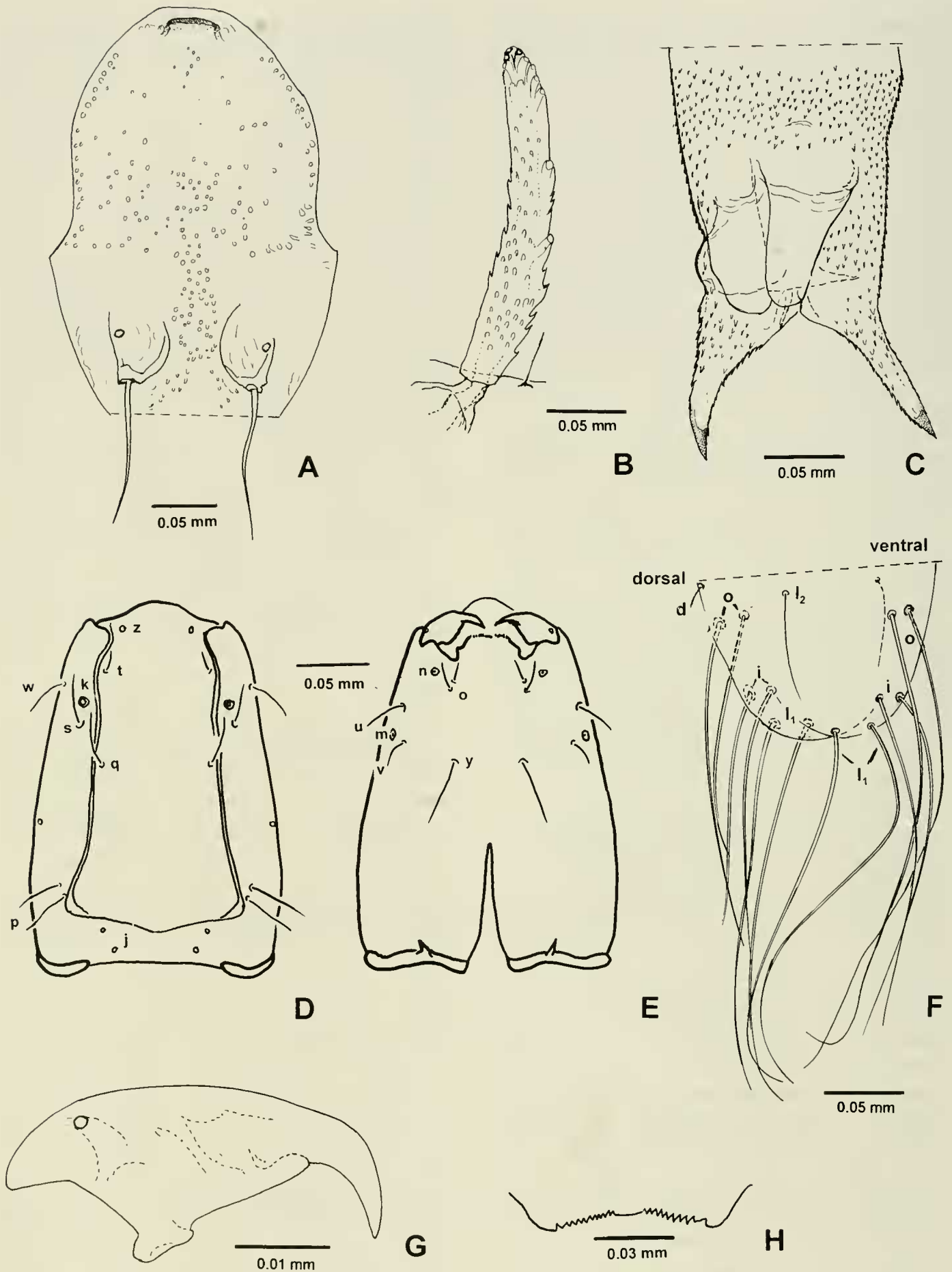


Fig. 6. Structures of *C. chaverrii*, pupa (A–C), fourth instar larva (D–H): (A) operculum; (B) respiratory organ, dorsomedial seta (dm); (C) anal segment in ventral view; (D) head capsule in dorsal view; (E) head capsule in ventral view; (F) anal segment in ventrolateral view; (G) left mandible in ventral view; (H) hypostoma.

in Costa Rica. However, the hind femur of *C. nigrigenus* is pale, with a conspicuous dark brown band only on its mid portion, the flagellomere 9 is longer, and the rounded pale spot straddling the middle of vein M_2 is connected anteriorly to the poststigmatic pale spots in cell r_3 and posteriorly to the pale spot in cell cua_1 .

Wirth and Blanton (1970) reviewed the *Culicoides decor* species group (as the *nigrigenus* group) for the Neotropics.

Although the immatures of two other species of the *decor* species group have been found in bromeliads, these have not been described and our description here is the first larval and pupal description of a species within the entire subgenus. The larvae have the elongate caudal setae typical of many species which occur in treeholes (Murphree and Mullen 1991).

The male and female adults were associated by rearing these from similar larvae and pupae which were collected from the same habitat.

Types.—Holotype ♂, allotype ♀, (both with pupal exuvia), Costa Rica, Puntarenas, Buenos Aires, Potrero Grande, ACLA-P, P. Internac. La Amistad, Est. Altamira, Cerro Frantzius, LS 334150N/574450E, 2,134 m, 20-VI-1999, LGCh-119, G. Chaverri [INBC]. Paratypes 15 ♂ (11 with pupal exuviae), 26 ♀ (8 with pupal exuviae), 7 pupae, 7 larval exuviae, as follows: Costa Rica, 2 km E Santa Elena, 26-VIII-1993, 1,540 m, A. Borkent, CD1559, 4 ♀ [CNCI]; Costa Rica, 2 km E Santa Elena, 26-VIII-1993, 1,540 m, A. Borkent, CD1,560, 1 ♂, 12 ♀ [♂, 8 ♀ CNCI, 2 ♀ INBC, 2 ♀, MLPA]; Costa Rica, Puntarenas, Buenos Aires, Potrero Grande, ACLA-P, P. Internac. La Amistad, Est. Altamira, Cerro Bioley, LS 332700N/572400E, 1,766 m, 15-VI-1999, BHB-103, B. Hernández, 2 ♂ (one with pupal exuvia) [INBC, CNCI]; Costa Rica, Puntarenas, Buenos Aires, Potrero Grande, ACLA-P, P. Internac. La Amistad, Est. Altamira, Cerro Bioley, LS 332700N/572400E, 1,766 m, 15-VI-1999, BHB-104, B. Hernández, 2 ♂ (with pupal exuviae)

[INBC]; Costa Rica, Puntarenas, Buenos Aires, ACLA-P, P. Internac. La Amistad, Est. Altamira, Cerro Bioley, 1,766 m, 20-VI-1999, LS 332700 572400, LGCh-117, G. Chaverri, 1 ♀ (with pupal exuvia) [MLPA], 1 ♂ (with pupal exuvia) [MLPA]; Costa Rica, Puntarenas, Buenos Aires, ACLA-P, P. Internac. La Amistad, Est. Altamira, Refugio Casacoca, 1,900 m, 21-VI-1999, LS 335000N/574500E, LGCh-121, G. Chaverri, 1 ♀ (with pupal exuvia), 3 ♂ (with pupal exuviae), 2 pupae [1 ♀, 1 ♂ INBC; 2 ♂, 2 pupae CNCI]; Costa Rica, Puntarenas, Buenos Aires, Potrero Grande, ACLA-P, P. Internac. La Amistad, Est. Altamira, Cerro Quemado, LS 336200N/575660E, 2,270 m, 22-VI-1999, LGCh-125, G. Chaverri, 5 ♀ (with pupal exuviae) [2 ♀ INBC; 2 ♀ CNCI; 1 ♀ MLPA], 5 ♂ (3 with pupal exuviae) [2 ♂ with pupal exuviae CNCI; 2 ♂ INBC; 1 ♂ with pupal exuviae MLPA], 4 pupae, 7 larval exuviae [INBC]; Costa Rica, Puntarenas, Buenos Aires, Potrero Grande, ACLA-P, P. Internac. La Amistad, Est. Altamira, Cerro Quemado, LS 336200N/575660E, 2,270 m, 22-VI-1999, LGCh 126, G. Chaverri, 1 ♀ (with pupal exuvia), 1 ♂ (with pupal exuvia), 1 pupa [INBC].

Derivation of specific epithet.—This species is named in recognition of the contribution of Guillermo Chaverri, a curator working at INBio, who has collected and reared large numbers of Nematocera, including most of the type series of *C. chaverrii*, from small aquatic habitats throughout Costa Rica.

Culicoides (Diphaomyia) ronderosae
Spinelli and Borkent, new species
(Figs. 1F, 7C–E, 11A)

Diagnosis.—Only species in the subgenus *Diphaomyia* Vargas with a pale spot at crossvein r-m lying entirely distad to crossvein, cell r_3 with three pale spots, cell m_1 with three pale spots, a pale spot lying adjacent to anterior side of midportion of cubital stem in cell m_2 , anal cell with one proximal and two distal pale spots, vein

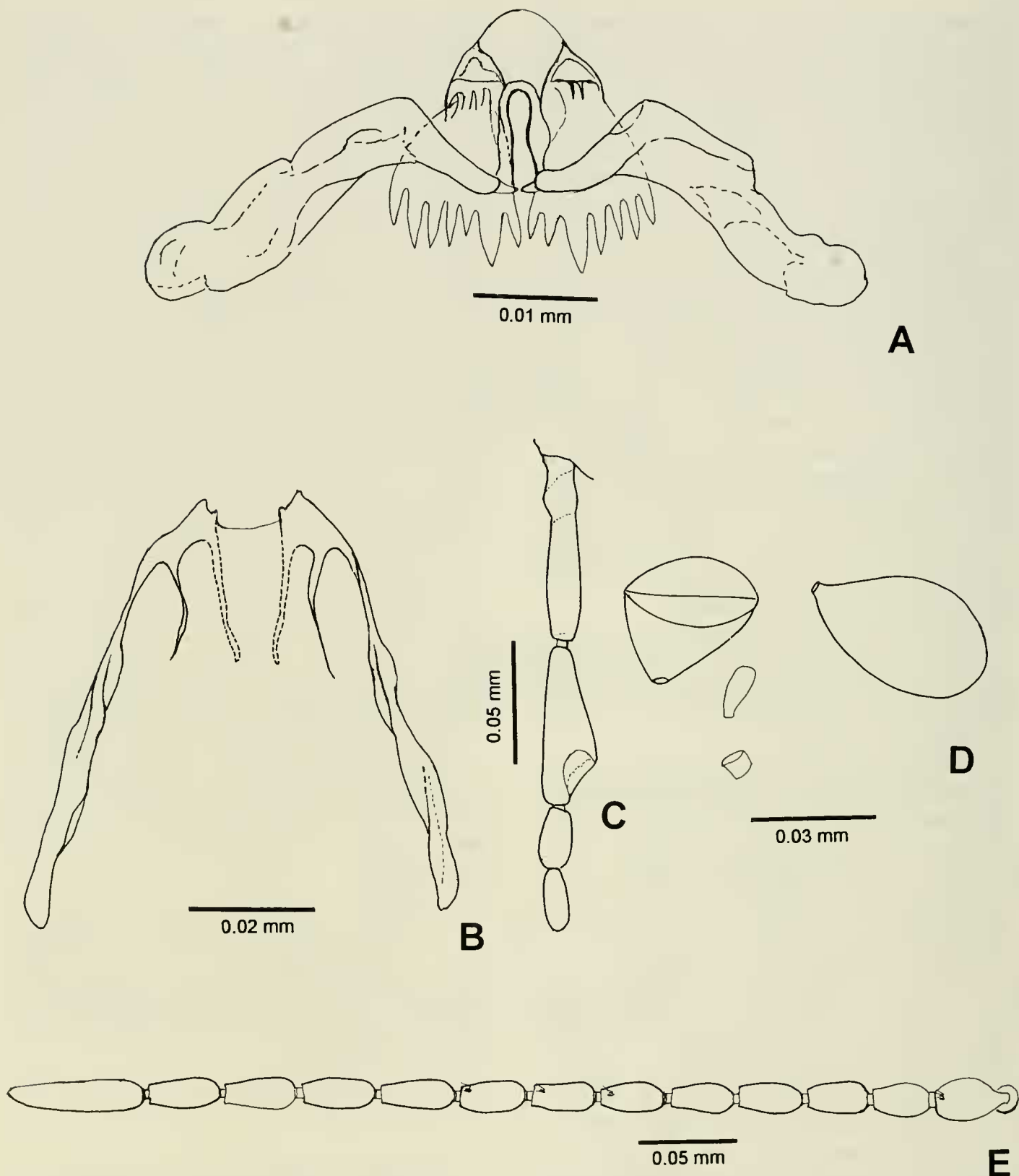


Fig. 7. Structures of *C. chaverri* (A, B) and *C. ronderosae* (C-E): (A) epipharynx in dorsal view; (B) hypopharynx in dorsal view; (C) palpus; (D) female spermathecae, duct ring; (E) female antenna.

Cu₂ with subapical pale spot, and a pale spot straddling base of vein M.

Description.—Male. Unknown.

Female. *Head*: Dark brown. Eyes apparently bare, separated by distance equal to diameter of one ommatidium. Flagellum (Fig. 7E) uniformly dark brown, flagello-

meres vasiform, without transition in length between proximal and distal series; AR 0.83; sensilla coeloconica on flagellomeres 1, 6-8. Palpus (Fig. 7C) dark brown; third segment slender, slightly swollen distally, with moderately large, shallow subapical pit; PR 3.20; P/H ratio 1.10. Mandible with

17 small teeth. *Thorax*: Dark brown. Scutum with distinct pattern, which in slide mounted specimen appears to include many small brown punctations around seta bases. Legs brown; femora with subapical, tibiae with subbasal pale rings, broad apex of hind tibia pale; hind tibial comb with four spines, one nearest spur longest. Wing (Fig. 1F), length 0.88 mm; width 0.43 mm; CR 0.57; with second radial cell in dark spot; membrane infuscated, with distinct pattern by small, definite, rounded pale spots, as follows: pale spot at crossvein r-m lying entirely distad to crossvein in cell r_3 ; poststigmatic pale spots in cell r_3 well separated, posterior one smaller, proximal to anterior one; two additional pale spots in cell r_3 , the distal one near apex of cell; cell m_1 with three pale spots; cell m_2 with four pale spots, one near wing margin, one anterior to cubital fork, one posterior to medial fork, one lying adjacent to anterior side of mid-portion of cubital stem; cell cua_1 with two spots, anal cell with one proximal, two distal pale spots; distal pale spots in cells r_5 , m_1 , m_2 , cua_1 and anal cell not abutting wing margin; vein CuA_2 with subapical pale spot; pale spot straddling base of vein M. Macrotrichia sparse but well distributed on distal half of wing, few in anal cell. Halter pale. *Abdomen*: Brown. Two ovoid, subequal spermathecae with very short necks (Fig. 7D), each measuring 48 by 28 μm ; rudimentary third, ring present.

Distribution.—*Culicoides ronderosae* is known only from the holotype from southern Costa Rica (Fig. 11A) at 1,000 meters elevation, collected in June.

Taxonomic discussion.—The presence of a pale spot at crossvein r-m lying entirely distal to the crossvein in cell r_3 (so that at least the posterior portion of r-m is dark) is characteristic of the following five Neotropical species of the subgenus *Diphaomyia*: *C. haematopotus* Malloch, *C. marinkellei* Wirth and Lee, *C. minasensis* Felipe-Bauer, *C. mirsae* Ortiz and *C. tarapaca* Spinelli and Wirth. The female of *C. ronderosae* is very distinctive, easily recognized

from all the mentioned species not only by the wing pattern features pointed out in the species diagnosis, but also by its long proboscis.

This new species keys to couplet 64 in Wirth and Blanton (1959) where it may be recognized by the combination of crossvein r-m with the pale spot lying entirely on the distal side of r-m, reaching anterior wing margin and cell r_5 with 2 distinct and separate pale spots distal to the poststigmatic pale spots.

There is no recent revision of the Neotropical *Culicoides* (*Diphaomyia*) but Wirth et al. (1988) provide numerical characters and photos of the wing patterns of the included Neotropical species.

Type.—Holotype ♀, Costa Rica, Puntarenas, San Vito de Java, 22-VI-1964, collector (?) [MLPA].

Derivation of specific epithet.—This species is named for Maria M. Ronderos [MLPA] in recognition of her important and continuing research on Ceratopogonidae.

***Culicoides cummingi* Spinelli and
Borkent, new species**
(Figs. 1G, 8A–C, 11A)

Diagnosis.—Large adults in the *daedalus* species group very similar to *C. pampoikillus* Macfie, from which it can be distinguished by the presence of sensilla coeloconica on all flagellomeres, the wing veins CuA_1 and CuA_2 dark to their apices, with the distal pale spots in anal cell oblique and well separated, and the absence of a pale spot posterior to the medial fork.

Description.—Male. Unknown.

Female. *Head*: Dark brown. Eyes bare, narrowly separated by distance shorter than diameter of one ommatidium. Flagellum (Fig. 8A) pale brown, especially flagellomeres 1–8; flagellomeres 1–8 short, 9–13 subcylindrical; AR 1.49 (1.42–1.62, $n = 10$); sensilla coeloconica on flagellomeres 1–13. Palpus (Fig. 8B) dark brown; third segment deeply swollen, with large, deep sensory pit opening by small pore; PR 1.88 (1.70–2.15, $n = 10$); P/H ratio 0.80 (0.76–

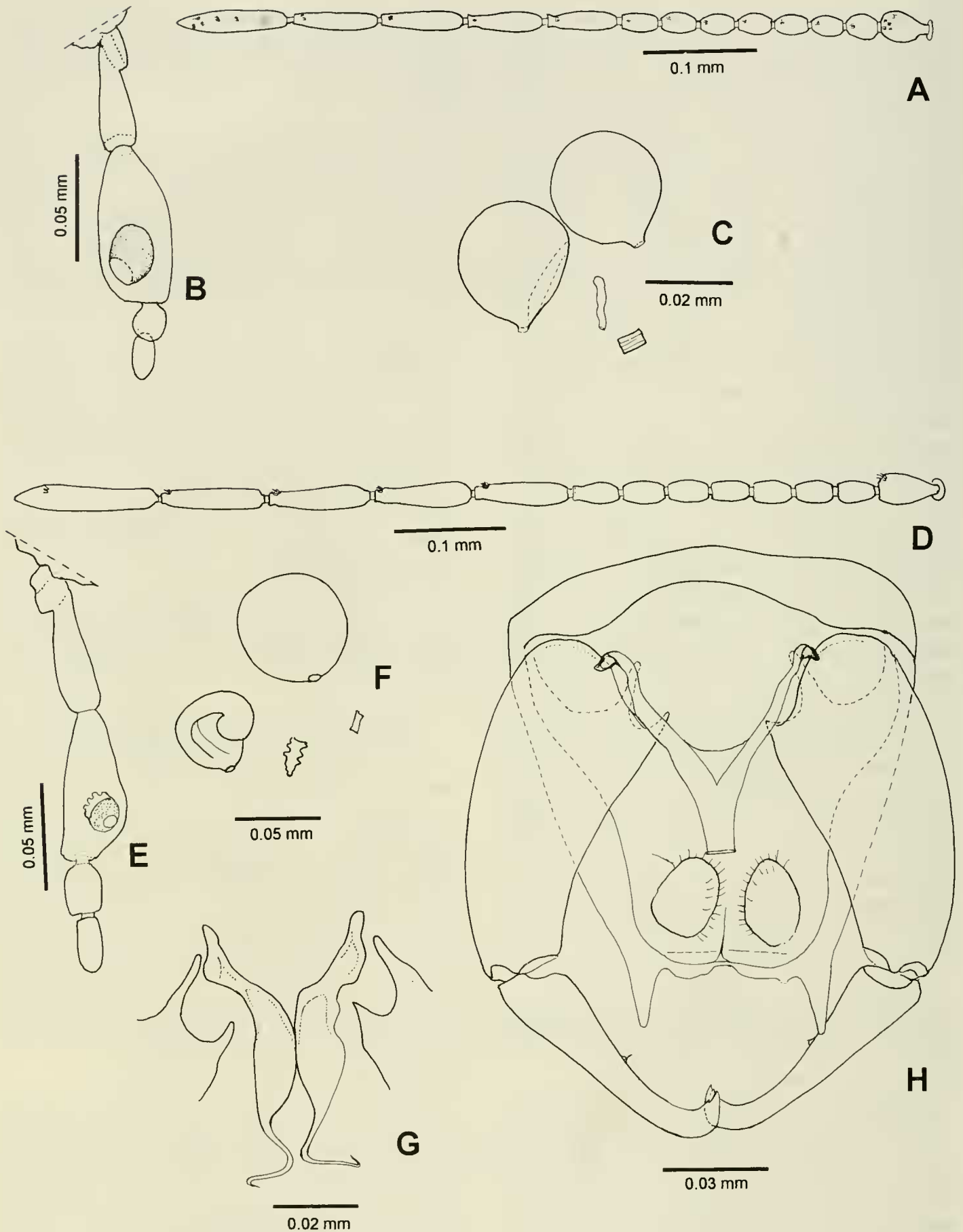


Fig. 8. Adult structures of *C. cummingsi* (A-C) and *C. picadoae* (D-H): (A, D) female antenna; (B, E) female palpus; (C, F) female spermathecae, duct ring; (G) parameres in ventral view; (H) male genitalia in ventral view.

0.86, $n = 10$). Mandible with 15–16 ($n = 10$) teeth. *Thorax*: Specimens not in position to describe the scutum pattern. Legs dark brown, knee spots blackish; fore, mid femora with subapical, and all tibiae with subbasal narrow pale rings; hind tibial comb with four spines, the second from the spur longest. Wing (Fig. 1G), length 1.20 (1.06–1.30, $n = 10$) mm; width 0.58 (0.52–0.62, $n = 10$) mm; CR 0.58 (0.56–0.60, $n = 10$); with second radial cell in dark spot; pale spot over crossvein r-m broadly abutting costal wing margin; poststigmatic pale spot in cell r_3 single, transverse; cell r_3 with main body of distal pale spot large, transverse, with small distal extension from posterior side; cell m_1 with elongate pale spot at wing margin; vein M_2 straddled by pale spot near its base; cell m_2 with pale spot at wing margin, another lying anterior to cubital fork; cell cua_1 with pale spot at wing margin, clearly separated from vein CuA_1 ; veins CuA_1 , CuA_2 dark to apex; anal cell with two oblique, well separated distal pale spots; small pale area at basal arculus, another lying on base of cubital stem. Macrotrichia dense, long, extending to bases of medial, anal cells. Halter pale. *Abdomen*: Brown. Two oval, subequal spermathecae (Fig. 1C), each measuring 32 (30–36, $n = 7$) by 26 (24–28, $n = 7$) μm ; rudimentary third, sclerotized ring present.

Distribution.—*Culicoides cummingi* is known only from mid elevations (1,050–1,800 meters) in the Talamanca mountains of Costa Rica (Fig. 11A).

Bionomic information.—This species is recorded from cloudforest habitat and has been collected from July till November. One specimen was collected with a malaise trap.

Taxonomic discussion.—*Culicoides cummingi* is a member of the *daedalus* species group, a group not placed to subgenus. This new species keys to couplet 51 in Wirth and Blanton (1959) where it may be distinguished from both *C. pampoikilus* and *C. commatis* Wirth and Blanton by the presence of three discrete pale spots in the anal

cell in *C. cummingi*. Additional features distinguishing *C. cummingi* and *C. pampoikilus* are given in the diagnosis above.

Culicoides cummingi shares the following features with *C. commatis*: presence of a small distal extension from the main body of distal pale spot in cell r_3 , veins CuA_1 and CuA_2 are dark to their apices, and by the absence of a pale spot posterior to the medial fork. However, *C. commatis* differs by its smaller size (wing length 1.02 mm), the presence of sensilla coeloconica only on flagellomeres 1, 3, 5, 7, 9–13, a stouter third palpal segment, the mandible with only 12 teeth, and the main body of the distal pale spot in cell r_3 not abutting the anterior wing margin.

No revision of the *daedalus* species group is available but some salient features, and especially those of the wings, are given by Wirth et al. (1988).

Types.—Holotype ♀, Costa Rica, Puntarenas, ACLA R.P. Zona Protector, Tablas Quijada del Diablo, 1,800 m, 3.1 NE de Mellizas, 16-X/10-XI-1996, E. Navarro, CD5024 [INBC]. Paratypes, 9 ♀, as follows: Costa Rica, Puntarenas, Buenos Aires, ACLA. PILA Est. Altamira, 1,450 m, 23-VIII/13-IX-1996, R. Villalobos, malaise trap, CD5007, 1 ♀ [CNCI]; Costa Rica, Cartago, Navarro, VII-1962, 1,050 m, Blanton, 8 ♀, light trap [7 ♀: MLPA; 1 ♀: USNM].

Derivation of specific epithet.—This species is named after Jeffery M. Cumming [CNCI] in recognition of his important contributions to Dipterology and his much appreciated assistance to the junior author for many years.

***Culicoides picadoae* Spinelli and
Borkent, new species**
(Figs. 1H, 8D–H, 11B)

Diagnosis.—Large adults in the *daedalus* species group very similar to *C. dumni* Wirth and Blanton, from which it can be distinguished by the poststigmatic pale spot in cell r_3 including distal portion of vein R_3 , the absence of pale spot in cell r_3 lying on

anterior side of vein M_1 , the distal pale spots in cells m_1 and m_2 broadly abutting wing margin, and the pale spot in cell cua_1 clearly separated from vein CuA_1 .

Description.—Male. Similar to female with usual sexual differences. Wing length 1.04 mm; width 0.44 mm; CR 0.54. *Genitalia* (Fig. 8H): Tergite 9 moderately short, broad, with large, triangular apicolateral processes, posteromedial margin distinctly notched; sternite 9 with very broad, shallow posteromedial excavation. Gonocoxite twice as long as greatest width, with ventral root very finely-pointed, dorsal root longer, slender; gonostylus distinctly shorter than gonocoxite, with slender hooked pointed apex. Parameres (Fig. 8G) separate, each with basal knob bearing long anterior projection; posteromedial projection slender, bent at base; midportion moderately swollen, straight; distal portion abruptly narrowed to slender, twisted, simple, filiform tip. Aedeagus with basal arch extending 0.50 of total length; lateral arms slender, moderately curved at tips; posteromedial projection tapered to simple, broad, truncated tip.

Female. *Head*: Dark brown. Eyes bare, narrowly separated by distance shorter than diameter of one ommatidium. Flagellum (Fig. 8D) with flagellomeres 1–8 pale, short, 9–13 brown, subcylindrical; AR 1.52; sensilla coeloconica on flagellomeres 1, (5), (7), 9–13. Palpus (Fig. 8E) dark brown; third segment large, moderately swollen, with small, shallow sensory pit opening by small pore; PR 2.25; P/H ratio 0.81. Mandible with 14 teeth. *Thorax*: Scutum dark brown, with sublateral pale bands. Legs dark brown, knee spots blackish; fore, mid femora with subapical, all tibiae with subbasal narrow pale rings; hind tibial comb with five spines, the two nearest the spur longest, subequal. Wing (Fig. 1H), length 1.60 mm; width 0.76 mm; CR 0.59; with base of second radial cell in dark spot; pale spot over crossvein r-m large, broadly abutting costal wing margin; poststigmatic pale spot in cell r_3 single, transverse, quad-

rate, including distal portion of vein R_3 , from where it turns abruptly forward to meet costa; distal pale spot in cell r_3 of same shape and size of poststigmatic pale spot and also of the dark spot between them; cell m_1 with elongate pale spot broadly abutting wing margin; vein M_2 straddled by pale spot near its midlength; cell m_2 with rounded pale spot at wing margin, another lying anterior to cubital fork; cell cua_1 with rounded pale spot broadly abutting wing margin, clearly separated from vein CuA_1 ; apices of veins M_1 , M_2 , CuA_1 and CuA_2 dark; anal cell with two oblique, narrowly separated distal pale spots, the posterior one abutting wing margin, one rounded pale spot far from wing margin in basal part of cell. Macrotrichia extending to bases of cell m_2 , anal cell. Halter pale. *Abdomen*: Brown. Two subspherical, unequal spermathecae (Fig. 8F), measuring 32 and 24 μm in diameter, respectively; rudimentary third, ring present.

Distribution.—This species is known only from two locations in the Talamanca mountains of Costa Rica (Fig. 11B), and appears to be a mid to high elevation species, recorded from 2,250–2,900 meters.

Bionomic information.—The holotype from 15 km N San Isidro de el General was taken with a light trap at Reserva Avalon, a few kilometers SW of División, in an area of oak cloudforest. The allotype was collected with a malaise trap in an open patch of vegetation surrounded by oak cloudforest. Adults have been collected in March and some time during the end of September to the end of November.

Taxonomic discussion.—*Culicoides picadoae* is a member of the *daedalus* species group, a group not placed to subgenus. This new species keys to couplet 44 in Wirth and Blanton (1959) where it may be distinguished by the presence of two pale spots in cell r_3 and one distal pale spot in cell m_1 . Wirth et al. (1988) provide a useful summary of features of species of the *daedalus* species group.

Culicoides picadoae is very similar to *C.*

dunni, from which it can be distinguished by the absence of a pale spot at midlength of vein M_1 . The male genitalia of *Culicoides antefurcatus* Wirth and Blanton is very similar to that of *C. picadoae* except that *C. antefurcatus* lacks the posteromedial excavation of sternite 9, has a somewhat proportionally longer gonostylus, and the mid portion of the paramere is more slender.

Eight of the 11 Neotropical species of the *daedalus* species group are known from both sexes (*C. antefurcatus*, *C. commatis*, *C. crescentis* Wirth and Blanton, *C. daedalooides* Wirth and Blanton, *C. luglani* Jones and Wirth, *C. phaenotus* Wirth and Blanton, *C. daedalus* Macfie and *C. pam-poikilus*). *Culicoides beaveri* Wirth and Barreto and *C. dunni* are known only as females and *C. pseudocrescentis* Tavares and Luna Dias only from the male. Of the nine other species of the *daedalus* species group we have recorded or which are expected to be in Costa Rica (Table 2), the male and female of *C. picadoae* share a similar wing pattern and differ from each of these other species. Therefore, although the male and female are rather different in size, we have considered them to be conspecific. They may actually represent two species.

Types.—Holotype ♂, Costa Rica, 15 km N San Isidro de el General, 2,250 m, 13/14-III-1999, A. Borkent, CD5002 [CNCI]; allotype ♀, Costa Rica, San Jose, 4 km E Villa Mills, 2,900 m, 26-IX/29-XI-1996, A. Picado, B. Gamboa, CD5012 [INBC].

Derivation of specific epithet.—We are pleased to name this species after Annia Julia Picado Calvo, a highly skilled and knowledgeable parataxonomist working at INBio. She has produced many thousands of superb slide preparations of Ceratopogonidae, has collected a large number of specimens for the collection (including the allotype of this species) and has helped in numerous other tasks in both the field and laboratory. Muchas gracias por su excelente trabajo Annia!

Culicoides zumbadoi Spinelli and
Borkent, new species
(Figs. 11, 9A–E, 11B)

Diagnosis.—Small adults in the *eublepharus* species group very similar to *C. florenciae* Messersmith, from which it can be distinguished by the narrowly separated eyes, the shorter flagellomeres 11 and 12 and proboscis, the reduced number of mandibular teeth, and the poststigmatic pale spots in cell r_3 lying obliquely, the posterior one barely perceptible.

Description.—Male. Similar to female with usual sexual differences. Wing length 0.80 mm; width 0.31 mm; CR 0.57. Genitalia (Fig. 9E): Tergite 9 elongate, slender, with short, triangular apicolateral processes, posteromedial margin not notched; sternite 9 with narrow, shallow posteromedial excavation. Gonocoxite $2.5\times$ as long as broad, with ventral root well developed foot-shaped, anterior and posterior portion stout, dorsal root longer, slender; gonostylus about equal in length to gonocoxite, with rounded, slightly hooked apex. Parameres (Fig. 9D) separate, each with simple basal knob; midportion bent, with expanded portion; distal portion bent anteriorly, gradually narrowing to slender, simple, filiform tip. Aedeagus with basal arch extending 0.56 of total length; lateral arms slender, moderately curved; posteromedial projection tapered to simple, narrow, rounded tip.

Female. *Head*: Brown. Eyes with numerous inter-ommatidial spicules, apparently narrowly separated. Flagellum (Fig. 9A) uniformly brown, flagellomeres 6–8 each longer than each of 9–12; AR 0.73; sensilla coeloconica on flagellomeres 1, 6–12. Palpus (Fig. 9B) brown; third with segment subapical, shallow rounded pit; PR 2.30; P/H ratio 0.67. Mandible with 13–14 teeth. *Thorax*: Uniformly brown. Legs brown; tibiae with subbasal pale rings, narrow apex of hind tibia pale; hind tibial comb with four spines, second from spur longest. Wing (Fig. 11), length 0.80 mm; width 0.37 mm; CR 0.60; brownish infuscated, with only

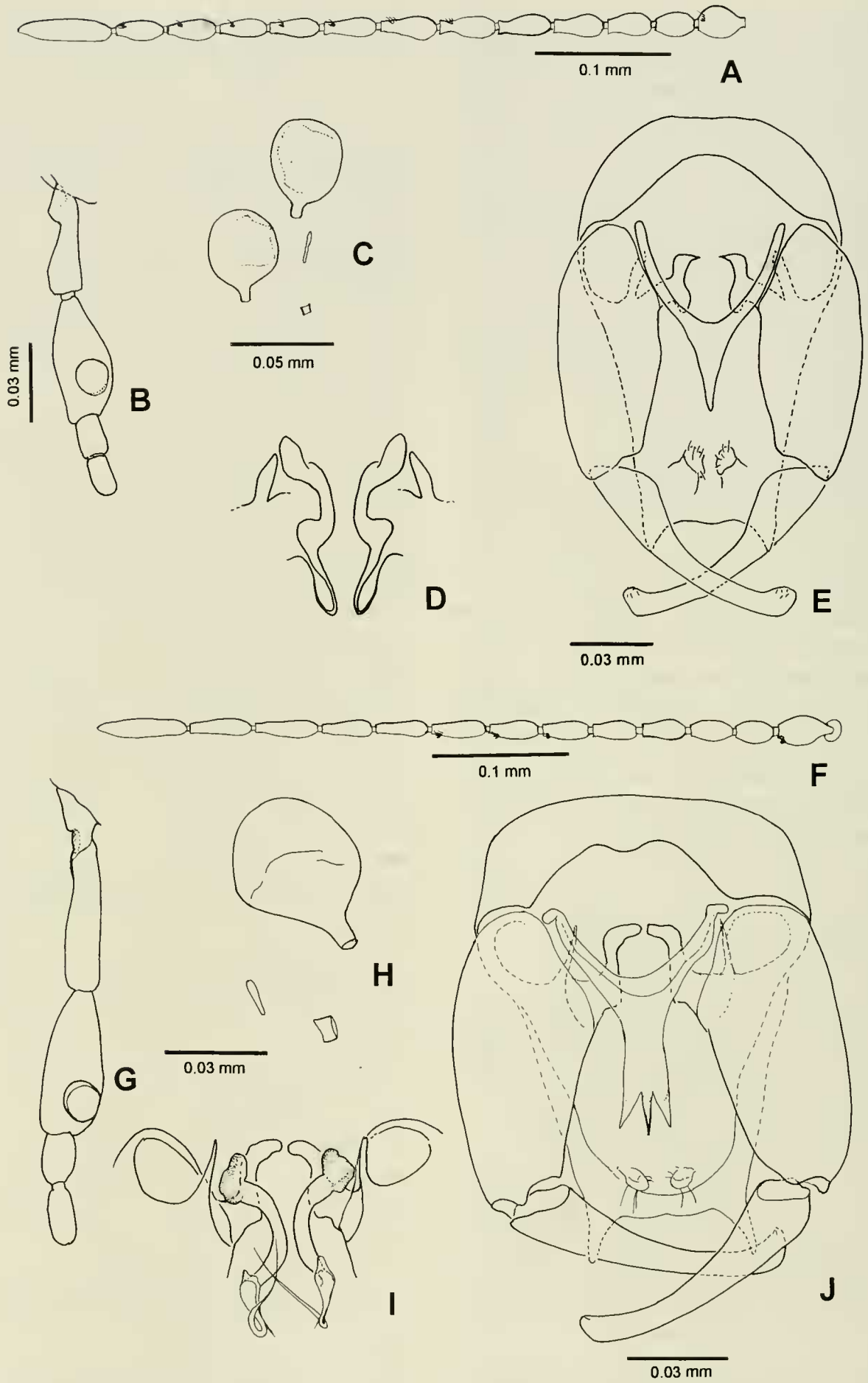


Fig. 9. Adult structures of *C. zumbadoi* (A-E) and *C. trifidus* (F-J): (A, F) female antenna; (B, G) female palpus; (C, H) female spermathecae, duct ring; (D, I) parameres in ventral view; (E, J) male genitalia in ventral view.

moderately distinct pattern of pale spots; second radial cell in dark spot; pale spot over crossvein r-m small, abutting costal wing margin; poststigmatic pale spots in cell r_3 lying obliquely, posterior one barely perceptible; distal pale spot in cell r_3 transverse, slightly concave distally, not abutting wing margin or vein M_1 ; two pale spots in cell m_1 , distal one well separated from wing margin; cells m_2 , cua_1 , anal cell with distal, rounded pale spots, first two abutting wing margin. Macrotrichia present on distal half of wing, few in cell cua_1 , anal cell, in one row to base of cell m_2 . Halter brown. *Abdomen*: Brown. Two ovoid, slightly unequal spermathecae with moderately long necks (Fig. 9C), measuring 44 by 34 μm , neck 10 μm , and 42 by 32 μm , neck 8 μm ; rudimentary third, ring present.

Distribution.—This species is known from only two specimens collected near the eastern coast of Costa Rica (Fig. 11B).

Bionomic information.—The male and female were collected with an aerial net near the water tank supplying water to the administration building in Reserva Carara, in mature lowland rainforest in July. The junior author collected very regularly at this location from July 2, 1993 till Jan. 24, 1994 and the presence of only two specimens suggests that the population of this species was low during this time.

Taxonomic discussion.—*Culicoides zumbadoi* is in the *eublepharus* species group and unplaced to subgenus. The following six species of the *eublepharus* group also have two spermathecae: *C. caldasi* Browne, *C. caucaensis* Wirth and Lee, *C. florenciae*, *C. guarani* Ronderos and Spinelli, *C. pabloi* Browne, and *C. tamboensis* Wirth and Lee. The new species may be distinguished from *C. florenciae* as indicated in the diagnosis above. Another similar species, *C. guarani*, mainly differs from *C. zumbadoi* in the greater contrasting wing pattern, each of flagellomeres 6–8 shorter than each of flagellomeres 9–12, flagellomeres 6–8 lacking sensilla coeloconica, and the fore and mid femora with subapical pale rings.

This new species keys out to the first half of couplet 94 in Wirth and Blanton (1959), except that flagellomeres 9–12 have sensilla coeloconica. Wirth and Blanton (1959: 420) provide a short diagnosis of the *eublepharus* group (as *transferrans* group) which requires some modification. The group now includes species in which the terminal flagellomeres are not elongated and species with two spermathecae. Wirth et al. (1988) provide numerical characters and wing photographs of the species included in this species group.

The male and female were associated by sharing the same patterns of pigmentation and being collected together at the same place and date.

Type.—Holotype ♂, allotype ♀, Costa Rica, 2 km NE Tarcoles, 20-VII-1993, A. Borkent, CD1481 [CNCI].

Derivation of specific epithet.—We are pleased to name this species after Manuel A. Zumbado [INBC], who has led the development of the outstanding Diptera collection at INBio and has been so supportive of our work.

Culicoides trifidus Spinelli and Borkent, new species

(Figs. 1J, 9F–J, 11B)

Diagnosis.—Medium sized adults in the *leoni* species group very similar to *C. benarrochi* Ortiz and Mirsa, from which it can be distinguished by the posterior poststigmatic pale spot located distinctly proximal to the anterior one, the reduced size of the distal pale spots in cell m_2 and the anal cell, and the sclerotized neck of spermatheca.

Description.—Male. Similar to female with usual sexual differences. Wing length 0.85 (0.80–0.90, $n = 2$) mm; width 0.31 (0.30–0.32, $n = 2$) mm; CR 0.56 (0.55–0.57, $n = 2$). Halter pale. *Genitalia* (Fig. 9J): Tergite 9 long, with stout, triangular apicolateral processes, small posteromedial notch; sternite 9 short, with broad, deep, posteromedial excavation. Gonocoxite 2.2× as long as broad, ventral root large, foot-shaped, posterior heel pointed, dorsal root

slender; gonostylus distinctly slender, only slightly curved. Parameres (Fig. 9I) separate, each with large, basal knob; basal portion slender, abruptly bent near base, distal portion sinuate, with evident ventral lobe, beyond which tapers to simple filamentous tip, recurved anteriorly. Aedeagus with lateral arms stout, strongly sclerotized; basal arch rounded, extending 0.25 of total length; posteromedial projection stout, with three pointed lobes, the medial one slightly longer than lateral ones.

Female. *Head*: Brown. Eyes with numerous interommatidial spicules, narrowly separated by distance shorter than diameter of one ommatidium. Flagellum (Fig. 9F) pale brown, flagellomere 8 slightly longer than 9; AR 0.81; sensilla coeloconica on flagellomeres 1, 6–8. Palpus (Fig. 9G) pale brown; third segment slightly swollen with moderately large, shallow pit; PR 2.25; P/H ratio 0.67. Mandible with 12 teeth. *Thorax*: Scutum dark brown, with sublateral, faint pale brown bands; scutellum, post-scutellum dark brown. Legs dark brown; fore and mid femora with subapical, tibiae with subbasal pale rings, hind tibia pale distally; hind tibial comb with four spines, one nearest spur longest. Wing (Fig. 1J), length 0.75 mm; width 0.38 mm; CR 0.61; with second radial cell in dark spot; pale spot over crossvein r-m small, barely abutting costal wing margin; poststigmatic pale spot in cell r_3 more or less separated into two distinct small round spots, posterior one located distinctly proximal to anterior one; distal pale spot in cell r_3 small, rounded, located in center of cell, not abutting wing margin; two pale spots in cell m_1 , the distal one well separated from wing margin; cell m_2 with very small distal pale spot not abutting wing margin, another lying anterior to cubital fork; cell cua_1 with rounded pale spot barely abutting wing margin, reaching distal portion of vein CuA_1 ; anal cell with one distal, very reduced pale spot well separated from wing margin. Macrotrichia very sparse on distal fourth of wing. Halter missing. *Abdomen*: pale brown. One pyriform

spermathecae with sclerotized neck (Fig. 9H), measuring 42 by 36 μm , neck 10 μm ; rudimentary third, ring present.

Distribution.—This species is known from the eastern lowland rainforest of Costa Rica (Fig. 11B).

Bionomic information.—The specimens from La Selva were collected with a light trap. The single male from 3 km E Cahuita was swept in a swamp forest in Cahuita National Park. Adults have been collected in March, April and October.

Taxonomic discussion.—*Culicoides trifidus* is in the *leoni* species group which is unplaced to subgenus. There are five other members in this species group, all Neotropical (Borkent and Spinelli 2000) and male and females are known for all. Male *C. trifidus* differs from all these by the presence of a broad, deep, posteromedial excavation of sternite 9 and the aedeagus with three posteriorly pointed lobes. Male *Culicoides hoffmani* Fox, a species placed in the subgenus *Haematomyidium* Goeldi have a very similar genitalia, but the parameres lack the evident distal ventral lobe, and their apices are pointed with lateral fringe of fine hairs. In addition, the female of *C. hoffmani* bears two well developed spermathecae, the posterior poststigmatic pale spot is located only slightly proximal to the anterior one, and the wing macrotrichia are more abundant.

This new species key out to couplet 69 in Wirth and Blanton (1959), where it may be distinguished by the following combination of features: poststigmatic pale spots in cell r_3 fused and not extending to vein M_1 ; macrotrichia present on about distal third of wing.

Culicoides trifidus differs further from *C. fieldi* Wirth and Blanton by the third palpal segment not greatly swollen, very reduced distal pale spots in cells m_2 and anal cell, absence of a pale spot anterior to the cubital fork, and by characters of the male genitalia. Wirth et al. (1988) provide numerical characters and wing photographs of the species included in the *leoni* species group.

The male genitalia of *C. trifidus* is very

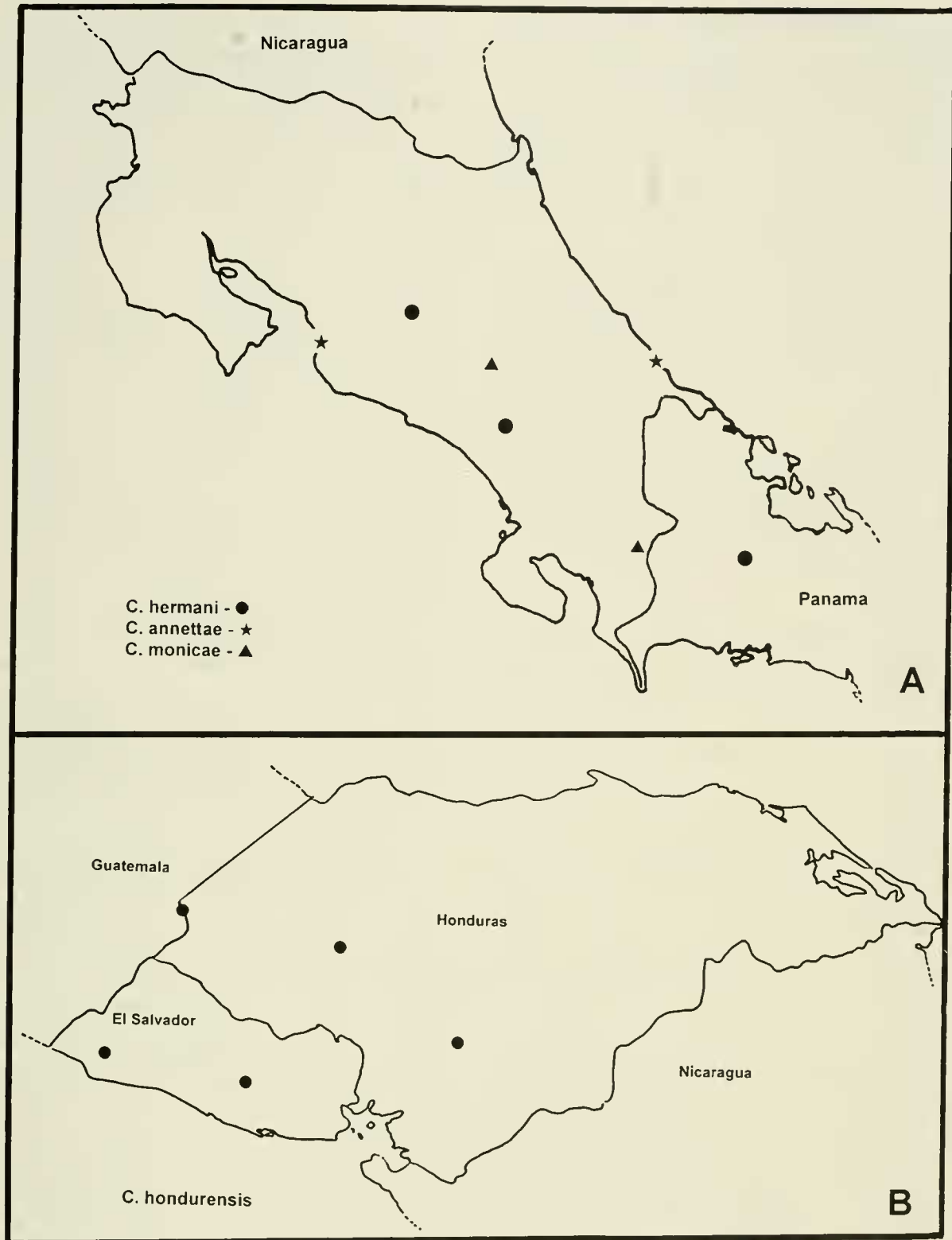


Fig. 10. Distributions of *Culicoides* species in Costa Rica and adjacent countries: (A) *C. hermani*—●, *C. annettae*—★, *C. monicae*—▲; (B) *C. hondurensis*.

similar to that of *C. (Haematomyidium) hoffmani* (Wirth and Blanton 1959: 436), sharing the trifid apex of the aedeagus and shape of ventral apodeme of the gonocoxite and it seems likely that the two are closely related (i.e., that the shape of the aedeagus is derived; however it likely groups other

species as well). This suggests that at least some members of the *leoni* species group belong in the subgenus *Haematomyidium*. In our opinion this subgenus is poorly defined and requires further study.

The two female paratypes are missing their antennae and therefore may not belong

to this species. However, in all other features they match the allotype female very well and are therefore placed here.

The male and female were associated by sharing pigmentation patterns and being collected at the same place and time at La Selva Biological Station.

Types.—Holotype ♂, allotype ♀, Costa Rica, Heredia, Puerto Viejo de la Sarapiquí, La Selva Biological Station, 7-V-1989, B.V. Brown, CD1260 [Holotype: INBC; allotype: CNCI]. Paratypes, 1 ♂, 2 ♀ as follows: Costa Rica, 3 km E Cahuita, 29-X-1993, A. Borkent, CD1641, 1 ♂ [CNCI]; Costa Rica, Heredia, La Selva Biological Station, Puerto Viejo de la Siripiquí, 24-IV-1989, B.V. Brown, 40 m, CD1170, 2 ♀ [INBC, CNCI].

Derivation of specific epithet.—This species is named *trifidus* (three-cleft) referring to the divided apex of the aedeagus.

CONCLUSIONS

Our study of the Ceratopogonidae of Costa Rica is in an early stage of development. It is clear that many more habitats require sampling during the different seasons, even though we have examined many hundreds of samples from throughout the country. There are two major difficulties hampering the interpretation of the biogeography of Costa Rican *Culicoides*. First, it is obvious that the distributions of many described species are poorly understood. There are quite a number of species like *C. davidi* Spinelli which is known from Costa Rica, Colombia and Trinidad but specimens are lacking from the intermediate areas. A second difficulty lies in our virtually nonexistent understanding of the phylogenetic relationships between species of *Culicoides*. It is uncertain which species are related to one another and therefore impossible to examine broader zoogeographic patterns.

One pattern apparent from the distribution maps of the new species described here is that most are distributed at higher altitudes in Costa Rica (Figs. 10, 11). This strongly suggests that further collecting at

mid to high elevations will produce additional undescribed species. Further to this, it would be helpful if future studies include distribution maps, as these more readily portray the distributions of the described species and are especially helpful in determining the relationship between endemism and altitude.

Table 2 lists the names and distributions of the 148 species of *Culicoides* which are now known from or are suspected to occur in Costa Rica. Of these, 42 are recorded for the first time (including the new species). There are eight species of *Culicoides* presently known only from Panama and these have not yet been discovered in Costa Rica (where they almost certainly occur). Our sampling has depended primarily on sweeping and malaise traps while the study of Panamanian *Culicoides* by Wirth and Blanton (1959) relied primarily on light traps and rearing. Further sampling with light traps in Costa Rica will likely produce these and other species as well. On the other hand, we are unsure about whether all of the species of *Culicoides* known only from Colombia will indeed be discovered in Costa Rica. Of these 20 species, *C. eldridgei* Wirth and Barreto, *C. brownei* Spinelli, *C. beaveri*, *C. youngi* Wirth, *C. rapososensis* Wirth and Barreto, and *C. teretipalpis* Wirth and Barreto have been collected at Rio Raposo on the west coast (lowland) and it is quite likely that these species will be found further north along the coast. *Culicoides florenciae* is recorded from about 1000 meters and the remaining 13 species are restricted to elevations above 1600 meters (*C. puracensis*, *C. suarezi* Rodriguez and Wirth and *C. marinkellei*: 3,250 m; *C. popayanensis* Wirth and Lee, *C. andicola* Wirth and Lee, *C. orjuelai* and *C. caucaensis*: 3,100 m; *C. tamboensis* and *C. andinus* Wirth and Lee: 2,500 m; *C. ameliae* Browne: 2,000 m; *C. caldasi*: 1,800 m; *C. pabloi* and *C. santanderi* Browne: 1,600 m). If these latter species are indeed restricted to higher elevations, which seems likely, they may not span the intervening eastern Panamanian

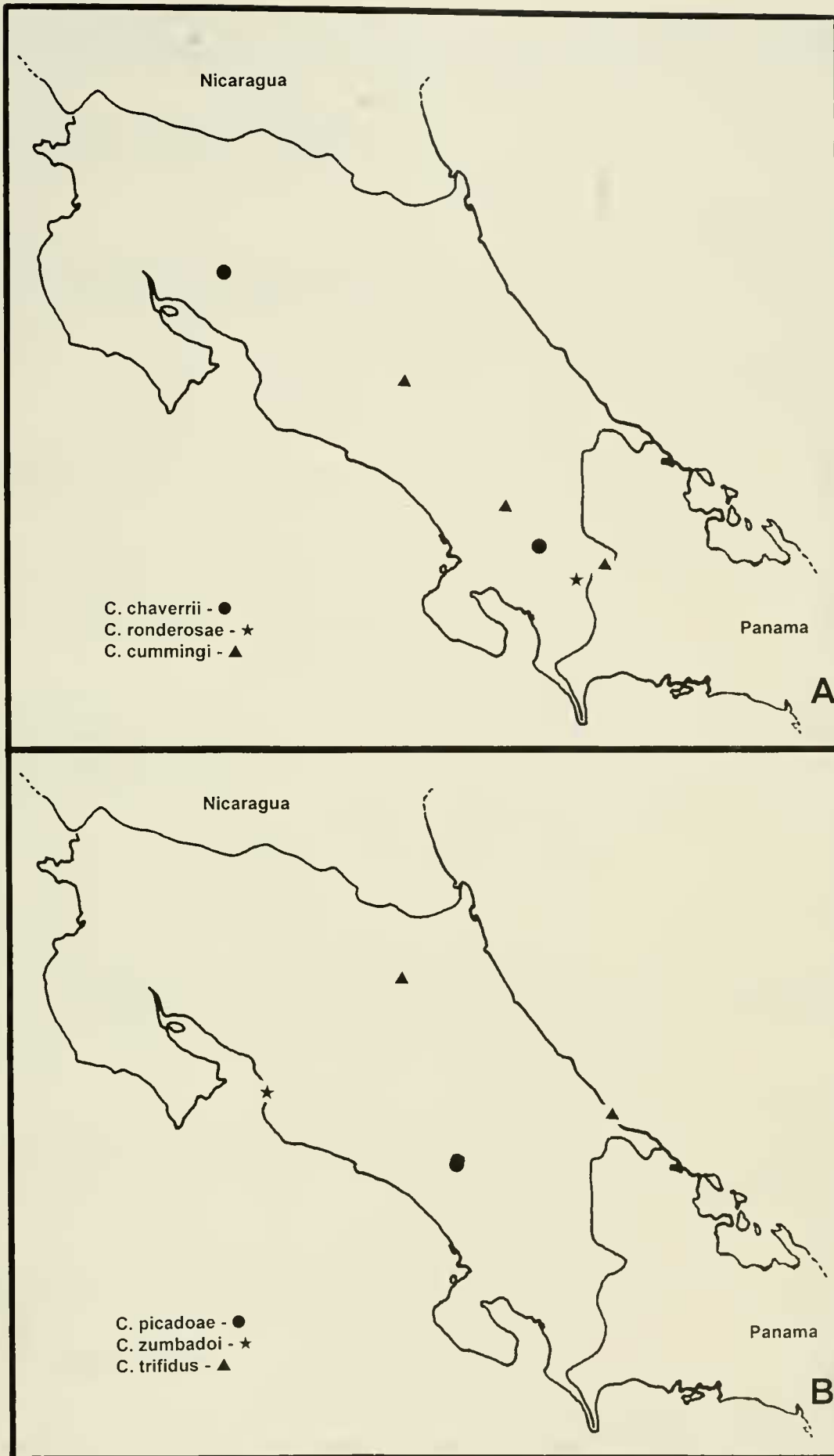


Fig. 11. Distributions of *Culicoides* species in Costa Rica: (A) *C. chaverrii*—●, *C. ronderosae*—★, *C. cummingi*—▲; (B) *C. picadoae*—●, *C. zumbadoi*—★, *C. trifidus*—▲.

Table 2. List of *Culicoides* known or suspected to occur in Costa Rica. [NR] indicates a new record for Costa Rica, although in some instances, the species has been previously recorded from both north and south of Costa Rica. [**] represent species expected to be discovered in Costa Rica. Distributions are arranged north to south and west to east.

Subgenus ANILOMYIA Vargas

- ameliae* Browne. Distr.—Colombia. [**]
chaverrii Spinelli and Borkent. Distr.—Costa Rica. [NR]
chrysonotus Wirth and Blanton. Distr.—El Salvador, Costa Rica, Panama.
covagarciai Ortiz. Distr.—Honduras, El Salvador, Costa Rica, Panama, Colombia, Venezuela.
efferus Fox. Distr.—Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru, Bolivia.
hayesi Matta. Distr.—Mexico (Tamaulipas), Honduras. [**]
lutealaris Wirth and Blanton. Distr.—Costa Rica, Panama.
marshi Wirth and Blanton. Distr.—Costa Rica, Panama, Colombia. [NR]
metagonatus Wirth and Blanton. Distr.—Nicaragua, Costa Rica, Panama, Colombia, Ecuador.
monicae Spinelli and Borkent. Distr.—Costa Rica. [NR]
nigrigenus Wirth and Blanton. Distr.—Mexico (Veracruz) and Central America south to northwestern Argentina. [**]
popayanensis Wirth and Lee. Distr.—Colombia. [**]
rostratus Wirth and Blanton. Distr.—Panama. [**]
trapidoi Wirth and Barreto. Distr.—Costa Rica, Colombia, Brazil. [NR]

Subgenus AVARITA Fox

- andicola* Wirth and Lee. Distr.—Colombia. [**]
hermani Spinelli and Borkent.—Costa Rica, Panama. [NR]
orjuelai Wirth and Lee. Distr.—Colombia. [**]
puracensis Wirth and Lee. Distr.—Colombia. [**]
pusilloides Wirth and Blanton. Distr.—Guatemala, Belize, Honduras, Nicaragua, Costa Rica, Panama.
pusillus Lutz. Distr.—USA (Florida) south to northern Argentina.
suarezi Rodriguez and Wirth. Distr.—Colombia. [**]

Subgenus BELTRANMYIA Vargas

- crepuscularis* Malloch. Distr.—Broadly distributed in Nearctic south to Costa Rica.

Subgenus CULICOIDES Latreille

- elutus* Macfie. Distr.—Mexico (Chiapas, Oaxaca) south to Panama. [NR]
luteovenus Root and Hoffman. Distr.—Mexico (DF, Chiapas, Oaxaca) south to Panama. [NR]
neopulicaris Wirth. Distr.—USA (Texas and Louisiana) south to Costa Rica.

Subgenus DIPHAOMYIA Vargas

- evansi* Wirth and Blanton. Distr.—Honduras, Costa Rica, Panama. [NR]
hondurensis Spinelli and Borkent. Distr.—Honduras, El Salvador. [**]
iriartei Fox, 1952. Distr.—Honduras, Costa Rica, Panama, Colombia, Venezuela, Brazil (Pará).
marinkellei Wirth and Lee. Distr.—Colombia. [**]
mirsaе Ortiz. Distr.—Panama, Venezuela, Trinidad. [**]
ronderosae Spinelli and Borkent. Distr.—Costa Rica. [NR]

Subgenus DRYMODESMYIA Vargas

- jamaicensis* Edwards. Distr.—USA (Texas, Florida), Central America and Caribbean south to Colombia and Venezuela.
panamensis Barbosa. Distr.—Mexico (Chiapas, Veracruz, Nayarit), Jamaica, Guatemala, Honduras, El Salvador, Costa Rica.
pilosus Wirth and Blanton. Distr.—Costa Rica, Panama, Brazil (Pará).
poikilonotus Macfie. Distr.—Mexico (Chiapas), Central America south to Brazil (Bahia), Colombia, Trinidad and Venezuela. [NR]

Subgenus GLAPHIROMYIA Vargas

- scopus* Root and Hoffman. Distr.—Mexico (DF), Costa Rica, Panama.
-

Table 2. Continued.

Subgenus HAEMATOMYIDIUM Goeldi

- annuliductus* Wirth. Distr.—Costa Rica, Panama. [NR]
bayano Wirth. Distr.—Costa Rica, Panama. [NR]
darlingtonae Wirth and Blanton. Distr.—Costa Rica, Trinidad. [NR]
debilipalpis Lutz. Distr.—Widespread from USA (Maryland, Kentucky, Nebraska south to Louisiana and Florida), Honduras south to Argentina.
eldridgei Wirth and Barreto. Distr.—Colombia. [**]
filiductus Wirth. Distr.—Belize, Honduras, El Salvador, Panama. [**]
germanus Macfie. Distr.—Costa Rica, Guyana. [NR]
ginesi Ortiz. Distr.—El Salvador, Costa Rica, Panama, Colombia, Venezuela, Trinidad, Brazil (Pará).
glabrior Macfie. Distr.—Honduras, Costa Rica, Panama, Colombia, Ecuador, Trinidad, Guyana, Surinam, Brazil (Pará). [NR]
hoffmani Fox. Distr.—Caribbean to Trinidad, Belize, Costa Rica.
imitator Ortiz. Distr.—Panama, Venezuela.
paraensis (Goeldi). Distr.—USA (Colorado, Nebraska, Pennsylvania, Wisconsin south to Louisiana and Florida) south to Argentina.
quasiparaensis Clastrier. Distr.—Honduras, El Salvador, Costa Rica, Panama, Colombia, Peru, French Guiana, Brazil (Amazonas, Rondônia). [NR]
spurius Wirth and Blanton. Distr.—Costa Rica, Panama. [NR]
youngi Wirth and Barreto. Distr.—Colombia. [**]

Subgenus HOFFMANIA Fox

- annettae* Spinelli and Borkent. Distr.—Costa Rica. [NR]
batesi Wirth and Blanton. Distr.—Guatemala, Colombia, Ecuador, Brazil (Pará), Bolivia. [**]
brownei Spinelli. Distr.—Colombia. [**]
davidi Spinelli. Distr.—Costa Rica, Colombia, Trinidad. [NR]
diabolicus Hoffman. Distr.—Mexico south to Venezuela and Ecuador (no records in Caribbean).
filarifer Hoffman. Distr.—Mexico (Chiapas, Veracruz) south to northern Brazil.
foxi Ortiz. Distr.—Mexico, Caribbean and Central America south to Bolivia and northeastern Argentina.
franklini Spinelli. Distr.—Mexico (Guerrero), Honduras, El Salvador, Costa Rica, Panama, Colombia, Brazil (Pará), Bolivia. [NR]
fusipalpis Wirth and Blanton. Distr.—El Salvador, Costa Rica, Panama, Colombia, Ecuador, Guyana, French Guiana, Brazil (Amazonas, Bahia, Pará, Rio de Janeiro), Bolivia.
heliconiae Fox and Hoffman. Distr.—Honduras to Ecuador; Venezuela, Trinidad and Tobago, Grenada.
hylas Macfie. Distr.—Mexico (Veracruz) south to Brazil (Amazonas) and Peru.
insignis Lutz. Distr.—USA (Alabama, Georgia, Florida), Central America and Caribbean south to central Argentina.
ocumarensis Ortiz. Distr.—Mexico (Oaxaca, Tabasco) south to northern Brazil.
palpalis Macfie. Distr.—Mexico (Chiapas) to Brazil (Amazonas) and Peru.
paraignacioi Spinelli. Distr.—Belize, Costa Rica, Colombia, French Guiana, northern Brazil.
polypori Wirth and Blanton. Distr.—Costa Rica, Panama, Colombia, Brazil (Amazonas).
pseudodiabolicus Fox. Distr.—Mexico (Puerto Nacional) south to Peru and northern Brazil.
tidwelli Spinelli. Distr.—Honduras, Costa Rica, Panama, Colombia, Ecuador.
trinidadensis Hoffman. Distr.—Coastal, Central America and Caribbean south to Venezuela, Colombia, Ecuador and Surinam.
verecundus Macfie. Distr.—Mexico (Chiapas) to Ecuador.
xanifer Wirth and Blanton. Distr.—Honduras, Costa Rica, Panama.

Subgenus MACFIELLA Fox

- phlebotomus* (Williston). Distr.—Mexico (Sinaloa) and Caribbean south to Ecuador and Brazil (Ceara, Goiás, Maranhão, Pernambuco).
willisoni Wirth and Blanton. Distr.—Mexico (Sonora), Honduras, Panama. [**]
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Table 2. Continued.

Subgenus MATAEMYIA Vargas

- azureus* Wirth and Blanton. Distr.—Panama. [**]
dalessandroi Wirth and Barreto. Distr.—Costa Rica, Panama, Colombia. [NR]
dicrourus Wirth and Blanton. Distr.—Costa Rica, Panama, Colombia, Ecuador.
mojingaensis Wirth and Blanton. Distr.—Panama. [**]
volcanensis Wirth and Blanton. Distr.—Panama, Colombia. [**]

Subgenus OECACTA Poey

- alahialinus* Barbosa. Distr.—Costa Rica, Panama, Colombia, Ecuador. [NR]
barbosai Wirth and Blanton. Distr.—USA (Florida) south to Ecuador. [NR]
cancer Hogue and Wirth. Distr.—Mexico (Sinaloa), El Salvador, Costa Rica.
furens (Poey). Distr.—USA (Massachusetts south to Florida and Texas), Mexico (Campeche, Santiago, Sinaloa, Veracruz) and Caribbean south to Ecuador and coastal Brazil.
gorgasi Wirth and Blanton. Distr.—Costa Rica, Panama, Colombia.

Subgenus unplaced, acotylus Species Group

- acotylus* Lutz. Distr.—Mexico (DF), Honduras, Panama, Venezuela, Trinidad, Surinam, Brazil (Mato Grosso, Pará). [**]
carsiomelas Wirth and Blanton. Distr.—Panama, Colombia, Brazil (Pará). [**]
teretipalis Wirth and Barreto. Distr.—Colombia. [**]

Subgenus unplaced, caridei Species Group

- raposoensis* Wirth and Barreto. Distr.—Colombia. [**]

Subgenus unplaced, carpenteri Species Group

- camposi* Ortiz and León. Distr.—Costa Rica, Panama, Colombia, Ecuador. [NR]
carpenteri Wirth and Blanton. Distr.—Costa Rica, Panama, Ecuador, Brazil (Amazonas), Bolivia.

Subgenus unplaced, daedalus Species Group

- antefurcatus* Wirth and Blanton. Distr.—Panama. [**]
beaveri Wirth and Barreto. Distr.—Colombia. [**]
commatis Wirth and Blanton. Distr.—Panama. [**]
crescentis Wirth and Blanton. Distr.—Mexico (Chiapas) to Colombia, northeastern Argentina. [NR]
cunningi Spinelli and Borkent. Distr.—Costa Rica. [NR]
daedaloides Wirth and Blanton. Distr.—Panama, Colombia. [**]
daedalus Macfie. Distr.—USA (Arizona, New Mexico), Mexico (Chiapas) to Colombia. [**]
dunni Wirth and Blanton. Distr.—Costa Rica, Panama.
pauypoikilus Macfie. Distr.—USA (Arizona, New Mexico), Mexico (Chiapas, Oaxaca) to Venezuela. [NR]
phaeonotus Wirth and Blanton. Distr.—Panama. [**]
picadoae Spinelli and Borkent. Distr.—Costa Rica. [NR]

Subgenus unplaced, dasyophrus Species Group

- dasyophrus* Macfie. Distr.—Colombia, Ecuador, Venezuela, Guyana, Brazil (Amazonas, Mato Grosso, Pará). [**]
rodriguezii Ortiz. Distr.—Panama, Venezuela. [**]

Subgenus unplaced, eublepharus Species Group

- caldasii* Browne. Distr.—Colombia. [**]
caucaensis Wirth and Lee. Distr.—Colombia. [**]
eublepharus Macfie. Distr.—Costa Rica, Panama, Colombia, Venezuela, Ecuador, northern Brazil.
florenciae Messersmith. Distr.—Colombia. [**]
pabloi Browne. Distr.—Colombia. [**]
propriipennis Macfie. Distr.—Mexico (Chiapas) to Panama, Ecuador, Venezuela and northern Brazil. [NR]
rangeli Ortiz and Mirsa. Distr.—Mexico (Oaxaca), to Ecuador, Bolivia, Venezuela, Trinidad, Brazil.
tamboensis Wirth and Lee. Distr.—Colombia. [**]
zumbadoi Spinelli and Borkent. Distr.—Costa Rica. [NR]

Table 2. Continued.

Subgenus unplaced, *fluvialis* Species Group

- balsapambensis* Ortiz and León. Distr.—Costa Rica to Ecuador, Brazil.
castillae Fox. Distr.—Guatemala, Honduras, Costa Rica, Panama, Ecuador, Venezuela, Trinidad.
fluvialis Macfie. Distr.—Honduras, Costa Rica, Panama, Colombia, Venezuela, Trinidad, Guyana, Brazil (Amazonas, Pará).
leopoldoi Ortiz. Distr.—Honduras and El Salvador south to Bolivia and northeastern Argentina.
tetrathyris Wirth and Blanton. Distr.—Honduras, Costa Rica, Panama, Ecuador, Trinidad, Surinam, northern Brazil. [NR]

Subgenus unplaced, *leoni* Species Group

- feldi* Wirth and Blanton. Distr.—Honduras, Costa Rica, Panama. [NR]
gabaldoni Ortiz. Distr.—Mexico (Tabasco) south to Ecuador, Venezuela, Trinidad, Brazil and Paraguay.
glabellus Wirth and Blanton. Distr.—Honduras to Ecuador, Trinidad, Brazil (Bahia, Pará).
trifidus Spinelli and Borkent. Distr.—Costa Rica. [NR]

Subgenus unplaced, *limai* Species Group

- galindoi* Wirth and Blanton. Distr.—Costa Rica, Panama. [NR]
limai Barretto. Distr.—el Salvador south to northeastern Argentina. [NR]
santanderi Browne. Distr.—Colombia. [**]
tenuilobus Wirth and Blanton. Distr.—Guatemala, Honduras, El Salvador, Panama. [**]
vernoni Wirth and Blanton. Distr.—Costa Rica, Colombia, Brazil (Pará), Bolivia. [NR]

Subgenus unplaced, *monticola* Species Group

- andinus* Wirth and Lee. Distr.—Colombia. [**]
magnipalpis Wirth and Blanton. Distr.—Panama. [**]
monticola Wirth and Lee. Distr.—Costa Rica, Panama, Colombia, Ecuador.

Subgenus unplaced, *pachymerus* Species Group

- almirantei* Wirth and Blanton. Distr.—Costa Rica, Panama. [NR]
atelis Wirth. Distr.—Panama. [**]
caprilesi Fox. Distr.—Panama, Colombia, Venezuela, Brazil (Mato Grosso, Pará). [**]
obnoxius Fox. Distr.—Colombia, Venezuela. [**]
pachymerus Lutz. Distr.—Guatemala, El Salvador, Costa Rica, Panama, Colombia, Brazil (Amazonas). [NR]
uniradialis Wirth and Blanton. Distr.—Panama, Colombia. [**]

Subgenus unplaced, *reticulatus* Species Group

- aureus* Ortiz. Distr.—Panama, Venezuela, Brazil (Amazonas), Bolivia, Paraguay, northeastern Argentina. [**]
guyanensis Floch and Abonnenc. Distr.—Panama, Venezuela to French Guiana, Trinidad and Tobago, Brazil (Pará, Pernambuco, Recife, São Paulo). [**]
lanei Ortiz. Distr.—Mexico (Veracruz), Honduras, Costa Rica, Panama, Venezuela, Trinidad, Brazil (Pará). [NR]
lyrinotatus Wirth and Blanton. Distr.—Nicaragua, Panama, Brazil. [**]
macrostigma Wirth and Blanton. Distr.—Costa Rica, Panama, Colombia.
paucienfuscatus Barbosa. Distr.—Costa Rica to Peru and Bolivia, Venezuela, Trinidad, Brazil (Amazonas, Pará).
pifanoi Ortiz. Distr.—Belize to Colombia, Venezuela, Trinidad, Brazil (Bahia, Pará).
reticulatus Lutz. Distr.—Honduras, Costa Rica, Panama, Colombia, Brazil (Bahia, Rio de Janeiro, Pernambuco, São Paulo).

Subgenus unplaced, *stigmalis* Species Group

- stigmalis* Wirth. Distr.—Mexico (Oaxaca), Guatemala, Costa Rica, Panama. [NR]

Subgenus unplaced, *venezuelensis* Species Group

- venezuelensis* Ortiz and Mirsa. Distr.—Costa Rica south to Central Argentina and Chile. [NR]

Miscellaneous Unplaced Species

- arubae* Fox and Hoffman. Distr.—USA (Texas), Caribbean (Aruba and Grenada) south to Colombia and Venezuela. [**]
trilineatus Fox, 1946. Distr.—Central America and Caribbean. Paraguay (?).
wokei Fox. Distr.—Costa Rica, Panama. [NR]

lowlands to the higher elevations of western Panama and Costa Rica.

There are now 285 species of *Culicoides* recognized in the region south of the United States (with the inclusion of the new species here) and this represents about 26% of the total diversity of Ceratopogonidae in this region. We believe that this percentage is in part an artefact produced by the lack of descriptions of a large number of undescribed species in some non-pestiferous genera such as *Dasyhelea* Kieffer, *Atrichopogon* Kieffer and *Stilobezzia* Kieffer. However, it remains clear that *Culicoides* is a huge and diverse group in the Neotropical Region and a great amount of research is required to better understand this genus. We plan to continue our study of Costa Rican *Culicoides* and further investigation is sure to reveal more undescribed species and new records, in addition to enhancing our understanding of the distribution of these insects.

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